Systematic Review

Ligamentum Teres Reconstruction May Lead to Improvement in Outcomes Following a Secondary Hip Arthroscopy for Symptomatic Microinstability: A Systematic Review

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Purpose: To present the indications, surgical technique, outcomes, and complications for patients undergoing arthroscopic reconstruction of the ligamentum teres (LT). **Methods:** Articles were included if they had postoperative patient-reported outcomes (PROs) for arthroscopic LT reconstruction. Studies were analyzed for patient demographics, clinical assessment and indications, radiographic and magnetic resonance imaging data, concomitant procedures performed, PROs, surgical techniques, intra-articular classifications, complications, and need for follow-up surgeries. For PROs, the standard mean difference was calculated. The proportion of patients achieving patient acceptable symptomatic state for postoperative modified Harris Hip Score ($\geq$74) was recorded. The number of patients achieving minimal clinically important difference for modified Harris Hip Score ($\Delta \geq 8$) was calculated. **Results:** The majority of the cases were revision arthroscopies. Of the 3 studies reporting on patients undergoing LT reconstruction due to microinstability, 4, 9, and 11 patients demonstrated a mean improvement of 25.7, 35.2, and 27.7 in modified Harris Hip, respectively. In addition, one of the studies reported a mean improvement of 31.1 and 4.2 in Nonarthritic Hip Score and visual analog scale, respectively. Of the 3 studies, the percentile of patients surpassing minimal clinically important difference and patient acceptable symptomatic state ranged between 50% and 100% and 33.3% and 88.8%, respectively. Overall, 5 patients underwent revision hip arthroscopy due to adhesions, iliopsoas impingement, and persistent microinstability, and 3 patients underwent a secondary hip arthroplasty due to refractory pain and radiographic evidence of hip osteoarthritis.

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Conclusion: Reconstruction of the LT may be considered in surgical management for patients with symptomatic hip instability due to soft-tissue causes. Current evidence supports for LT reconstruction predominantly for patients experiencing refractory instability following previous hip preservation procedures. Patients' expectations as well as the relatively high reoperation rate (i.e., 33%) should be discussed before the procedure. **Level of Evidence:** Level IV, systematic review of Level IV studies.

Instability of the hip joint is associated with a wide array of pathologies involving the joint and its surroundings, including damage to articular cartilage, labral tears, hamstring tendinitis, peritrochanteric injuries, and patellofemoral dislocations.[1] Stability of the hip joint is grossly determined by the geometry of the bony architecture (i.e., the acetabulum and the proximal femur) and by the functional and mechanical integrity of the peri-articular soft tissues (e.g. capsule, labrum, ligamentum teres).[2] Until recently, most of the literature on instability of the hip joint has overlooked the role of the ligamentum teres (LT). However, in recent years, the hypothesis of the LT being a vestigial structure was disputed by demonstrating its function as a hip stabilizer, particularly in mid-flexion, abduction/adduction, and rotation.[1,3,4]

Instability of the hip is initially managed conservatively with physical therapy, activity modifications, and nonsteroidal anti-inflammatory medications.[5,6] For those patients who do not respond to nonsurgical treatment, a thorough evaluation of the contributing factors should be completed preoperatively, specifically the femoroacetabular bony architecture, the integrity of the labrum, ligamentous laxity, and the dynamic stabilizers (e.g., iliopsoas).[5] Clinical assessment of hip instability should include the O'Donnell test of LT pathologies.[7] In addition, preoperative magnetic resonance imaging (MRI) has demonstrated variable accuracy in diagnosing tears of the LT; however, a recent systematic review demonstrated an overall sensitivity and specificity of 82.2% and 88.6%, respectively.[8]

Arthroscopic management of patients with findings of LT pathology may benefit from debridement of the tear and resection of the central acetabular osteophytes. However, in patients with marked instability, a cautious debridement should be performed to avoid exacerbating the instability.[9] Despite the correct decision-making, a subset of these patients may still experience instability and pain following the procedure.[6] Simpson et al.[10] were the first to describe the technique for LT reconstruction, offering yet another line of treatment for this patient population. LT reconstruction is mostly performed to restore the stability of the hip joint by implanting a graft that spans between the femoral head and the acetabulum via 2 tunnels, thereby recreating the function of the impaired native LT.[6,11] Despite the significance and the high prevalence of this pathology, due to its technically demanding procedure, there remains a paucity of data regarding LT reconstruction including indications, techniques, outcomes, and complications.

The purpose of this study is to present the indications, surgical technique, outcomes, and complications for patients undergoing arthroscopic reconstruction of the LT. The first hypothesis of this study is that the predominant indication for LT reconstruction would be instability of the hip joint, mostly presented following an unsuccessful primary hip arthroscopy. The second hypothesis is that these patients would have favorable outcomes following the procedure since their refractory symptoms were likely due to persistent instability.

Methods

This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act. Details that might disclose the identity of the subjects under study have been omitted. This study was approved by the institutional review board (5276)

Study Selection

A comprehensive literature search was completed in January 2020 using the PubMed, Embase, and Cochrane databases to identify articles reporting on patient-reported outcomes (PROs) following LT reconstruction. The search was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses)[12] guidelines and included the following key words: hip ligamentum teres, hip ligamentum teres reconstruction, femoral head ligament, ligamentum teres femoris, ligamentum teres of the hip, therapy, and treatment. The full search algorithm can be found in the Appendix Table 1, available at www.arthroscopyjournal.org.

Following the literature search, 2 reviewers (J.S. and M.J.Y.) examined the titles and abstracts to select the relevant studies for full-text review. During the full-text review, the bibliographies of all articles were analyzed for additional studies. Articles were included if they reported postoperative PROs of patients who underwent hip arthroscopic surgery and received LT reconstruction. In addition, abstracts, review articles, technical notes, systematic reviews, cadaveric studies, case reports, and studies with overlapping patient populations were excluded. Studies not available in English also were excluded.

Studies that met all inclusion and exclusion criteria were analyzed for patient demographics, clinical assessment and indications, radiographic and MRI data, concomitant procedures performed, PROs, surgical techniques, intra-articular classifications, complications, and need for follow-up surgeries.

Quality Assessment

Two authors (J.S. and M.J.Y.) independently assessed each selected article using the validated Methodological Index for Non-randomized Studies (MINORS) criteria.[13] This scoring system generated a numerical score of 24 for each study based on the following: data-collection process, endpoints, follow-up rate, statistical analysis, and when applicable, the quality of the control group.

Demographics

Demographic data on each study cohort were collected and analyzed. Demographic factors included number of hips, sex, age at surgery, follow-up time for PROs, and whether surgeries were primary or revision cases.

Surgical Indications

Specific indications for LT reconstruction based on medical history, patient symptoms, and physical examinations were recorded. Range of motion (ROM) as well as any specific tests or scores used to measure instability were additionally collected and analyzed.

Radiographic Findings and LT Tear Classification

For studies reporting on radiographic findings, the following measurements were collected: lateral center edge angle, anterior center edge angle, center edge angle (CEA), acetabular inclination, and alpha angle. The degree of LT tears was preoperatively reported based on MRI. In addition, Domb and Villar LT classifications were reported when the LT tear was assessed intraoperatively.[14,15]

Procedures

Studies' surgical procedures were evaluated. Concomitant procedures were reported in addition to surgical equipment, portals, and type of graft used for reconstruction. Other specific details to the surgical techniques for the LT reconstruction were collected and outlined for each study. When available, intraoperative assessments of the reconstructed LT were also reported.

Rehabilitation

Studies were examined for rehabilitation protocols following surgery. Restrictions to weight-bearing or ROM were noted. Medication management also was recorded when available.

Secondary Surgeries and Complications

Patients requiring secondary surgeries, whether a revision arthroscopy or conversion to total hip arthroplasty (THA), were recorded in addition to the timing of the surgery. Moreover, the details and timing of any postoperative complications were reported.

Outcomes

The following PROs and patient satisfaction were recorded when available in each respective study: modified Harris Hip Score (mHHS), Nonarthritic Hip Score (NAHS), international Hip Outcome Tool, and visual analog scale.

Data Analysis

For studies reporting preoperative PROs, postoperative PROs, and a measure of dispersion (range, standard deviation, or 95% confidence interval [CI]), the standard mean difference was calculated as described by Griffin et al.[16] If the SD was not available, the range or 95% CI was used to approximate SD.[17,18] Additionally, the proportion of patients achieving patient acceptable symptomatic state (PASS) for postoperative mHHS ($\geq$74) was recorded.[19] Similarly, when preoperative data were provided, the number of patients achieving minimal clinically important difference (MCID) for mHHS ($\Delta \geq 8$) was calculated.[19]

Results

Study Selection

The literature search of the PubMed, Embase, and Cochrane databases identified a total of 74 studies (36 studies, 36 studies, and 2 studies, respectively). Twenty-two studies were identified as duplicates and eliminated. The initial screening led to the exclusion of 7 additional studies. Forty-five articles underwent full-text review, of which 41 were excluded. An additional study was excluded due to overlapping patient populations.[20] The remaining 3 studies included 24 arthroscopic LT reconstruction cases (22 patients). The complete literature search is depicted in Fig 1. Each study's respective level of evidence and MINORS score are reported in Table 1.

Demographics

Of the entire patient population, the weighted mean patient age at the time of surgery was 31.1 (17.2-48.0) years old. There were 22 female and 2 male patients, all of whom had minimum 1-year follow-up. Collectively, follow-up time ranged from 12 months to 72 months. In addition, the majority of cases were revision hip arthroscopies with all patients reported by Philippon et al.[21] and O'Donnell et al.[11] having undergo at least one prior arthroscopy for femoroacetabular impingement (FAI), labral tear, and/or LT tear. All patients reported on by Philippon et al.[21] were recreational or semi-professional athletes. Further demographics are depicted in Table 2.

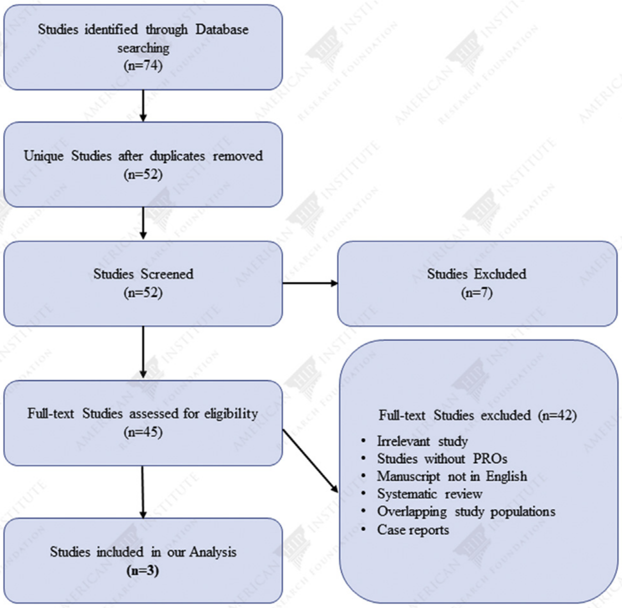

Fig 1. Patient selection. (PROs, patient-reported outcomes.)

Indications for Surgery

Symptomatic instability and high-grade ligamentous laxity were common findings across all study cohorts. In addition, Rosinsky et al.[9] reported that 7 of 11 cases had Ehlers-Danlos syndrome and 1 patient had rheumatoid arthritis. Furthermore, the majority of cases were revision arthroscopies, and it was noted throughout all 3 studies that for many of these cases, instability was not resolved by their primary surgery and thus indicated for LT reconstruction. Specifically, Philippon et al.[21] reported LT injury being one of the indications for the index procedure. O'Donnell et a.[11] noted that all patients previously underwent excision of a completely torn LT and capsular plication. All patients enrolled in Rosinsky et al.[9] had microinstability, indicated by Beighton score >4 and 7 of the 11 patients had EDS. Beside instability, common presenting symptoms for patients included pain in the groin or buttock regions, painful catching, and a "giving out" sensation of the hip. Rosinsky et al.[9] also reported that hip pain and instability in the presence of an LT tear >50% and normal acetabular coverage is a potential indication for LT reconstruction.

Physical Examination

Philippon et al.[21] discuss, in their article, the use of the axial traction apprehension and external rotation dial test in identifying instability. All patients in this cohort had positive hip dial tests preoperatively. Rosinsky et al.[9] recorded anterior and posterior impingement, apprehension, Beighton score, and O'Donnell LT tests pre- and postoperatively when available. All cases recorded positive anterior impingement and Apprehension tests as well as Beighton scores >4 preoperatively. The number of positive anterior impingement and Apprehension tests decreased to 6 and 3 at minimum 2-year follow-up, respectively. Two cases recorded positive posterior impingement tests preoperatively but none postoperatively. The O'Donnell LT test was performed on 3 hips, of which all demonstrated positive findings preoperatively and 2 demonstrated positive findings postoperatively at minimum 2-year follow-up.[9] ROM and physical examination data are summarized in Table 3.

Radiographic Findings and LT Tear Classification

Two studies reported the preoperative radiographic findings of their respective study populations.[9,21] Philippon et al.[21] calculated an average CEA of 26.5°. Rosinsky et al.[9] reported mean acetabular inclination, lateral center edge angle, anterior center edge angle, and alpha angle, which were 4.67°, 29.36°, 30.27°, and 51.70°, respectively.

All 3 studies used the Domb and/or Villar classification systems to evaluate the thickness of the LT tear.[11,21] Philippon et al.[21] used the Villar classification to report 3 patients with type I, complete tears and 1 patient with a type III, degenerative tears. O'Donnell et al.[11] also used the Villar classification and reported that all 9 of their patients had type I, complete tears. According to a preoperative MRI, Rosinsky et al.[9] reported 5 full-thickness tears, 5 partial tears, and on one case's MRI, no tear was noted. Rosinsky et al.[9] also reported the intraoperative findings of the LT. According to the Domb classification system, 4 cases had type II, high grade (>50%) tears whereas the remaining 7 had type III, complete tears. According to the Villar classification, 5 cases had type I, complete tears, 4 cases had type II, partial tears, and 2 cases had type III, degenerative tears.

Surgical Techniques

Procedure details and concomitant procedures are outlined in Table 4. Some variation exists between the procedures of the 3 studies. For tunnel positioning, Philippon et al.[21] passed a guidewire through the femoral neck to exit within the fovea capitis while under fluoroscopy. A femoral tunnel was created over the guidewire using a reamer. The posteroinferior portion of the cotyloid fossa was debrided of soft tissue. A double loaded biocomposite suture anchor was placed in the footprint of the LT, avoiding recessing the anchor within the acetabulum. Sutures were then retrieved through the midanterior portal and the graft was introduced through this portal using suture limbs that pass through the ends of the graft. The acetabular side of the graft was secured to the cotyloid

Table 1. Level of Evidence and MINORS

Study	Level of Evidence	MINORS
Philippon et al.,[21] 2012	IV	13
O'Donnell et al.,[11] 2020	IV	15
Rosinsky et al.,[9] 2020	IV	15

MINORS, Methodological Index for Non-randomized Studies.

Table 2. Demographic Data from Selected Studies

Study	No. of Hips	Sex, F:M	Age, mean (range)	Follow-up, mean (range)	Previous Surgeries
Philippon et al.,[21] 2012	4	4:0	36.0 (30.0-41.0)	31.0 (12.0-60.0)	All revision cases
O'Donnell et al.,[11] 2010	9	9:0	30.0 (22.0-48.0)	(12.0-24.0)	All revision cases
Rosinsky et al.,[9] 2020	11	9:2	30.3 (17.2-43.7)	44.27 (24.0-72.0)	4 revision cases 7 primary cases

F, female; M, male.

fossa using alternating half hitches. The femoral end was pulled through the femoral tunnel with an arthroscopic grasper. Approximately 2.5 cm of the graft was left within the joint with the leg externally rotated and extended to avoid loss of movement after fixation.

For tunnel positioning, O'Donnell et al.[11] passed a guidewire through the femoral neck using a separate incision over the distal part of the greater trochanter. Then the guidewire was advanced through the femoral head to exit the head fovea. The guidewire was located centrally in the neck in the anteroposterior plane and slightly more proximal on the greater trochanter than a hip fracture fixation screw to obtain better accessibility to the acetabular footprint of the LT. The femoral tunnel was then drilled 1 mm larger than the diameter of the graft. The acetabular fixation was performed with two 2.3-mm hip anchors that were inserted via the femoral tunnel into the acetabular floor. One arm of each anchor stitch was passed through the loop end of the doubled graft, and the graft was then introduced through the femoral tunnel into the joint. The anchor sutures were tied using a knot pusher which also passed through the tunnel. Firm tensioning of the graft was performed while the hip was left in traction and externally rotated 40° using the nonabsorbable stitch.

Lastly, Rosinsky et al.[9] used a customized curved metal probe in the tip of the fovea as a fluoroscopic target. Then, they inserted a guidewire from the lateral cortex of the femur to the tip of the probe. The acetabular footprint was prepared through either the femoral tunnel or an established portal using a radiofrequency device, shaver, and burr. The leg was placed in 15° of abduction and 15° of internal rotation while the guidewire was passed through the femoral tunnel to meet the acetabular footprint of the LT. A 3.2-mm drill was then used for perforation of the inner table. The graft was inserted to the joint through the modified anterior portal. A cortical button fixation device was inserted into the acetabular tunnel and flipped. With a shuttle suture, the femoral end of the graft was passed antegrade into the femoral tunnel. Fixation of the graft in the femoral tunnel was performed with the limb in partial traction and 60° to 90° of external rotation to prevent overtensioning of the graft.

Intraoperative Assessment of the LT Reconstruction

O'Donnell et al.[11] and Rosinsky et al.[9] assessed the graft integration following the reconstruction. O'Donnell et al.[11] assessed this during the arthroscopy by rotating the hip into full internal and external rotation to confirm the acetabular attachment to the graft without separation from the bone. A concentric localization of the femoral head per fluoroscopy indicated a functional LT. Rosinsky et al.[9] also performed intraoperative assessments with and without traction. External and internal rotation examinations were performed to confirm the concentric position of the femoral head within the hip joint.

Postoperative Rehabilitation and Medications

Both Philippon et al.[21] and Rosinsky et al.[9] reported postoperative rehabilitation protocol and medication administration. Both therapy programs restricted weight-bearing and ROM as well as administered medication focused on preventing heterotopic ossification (Table 5).

Patient-Reported Outcomes (PROs)

All 3 studies reported on varying combinations of the following PROs: mHHS, NAHS, international Hip Outcome Tool, and visual analog scale. Two studies included patient satisfaction on a scale of 0 to 10, with

Table 3. Range of Motion

Range of Motion	Philippon et al.,[21] 2012 Preoperative	Rosinsky et al.,[9] 2020 Preoperative	Rosinsky et al.,[9] 2020 Postoperative
Flexion, ° mean ± SD, [95% CI] or (range)	112 (106-120)	109.4 ± 5.2 [97.5-121.4]	106.4 ± 15.7 [95.8-116.9]
Abduction, ° mean ± SD, [95% CI] or (range)	49 (40-55)	–	–
Adduction, ° mean ± SD, [95% CI] or (range)	24 (15-30)	–	–
Internal rotation, ° mean ± SD, [95% CI] or (range)	44 (30-56)	19.4 ± 3.9 [10.3-28.5]	19.1 ± 11.4 [11.5-6.7]
External rotation, ° mean ± SD, [95% CI] or (range)	43 (20-59)	38.9 ± 3.9 [29.9-47.9]	33.6 ± 11.2 [26.1-41.2]

CI, confidence interval; SD, standard deviation.

Table 4. Procedural Information

Study	Concomitant Procedures	Equipment	Portals	Type of Grafts	Graft Fixation
Philippon et al.,[21] 2012	Reapproximation of the capsule—all patients	2.0-mm guidewire 8-mm reamer Curette	Midanterior Anterolateral Posterolateral	Iliotibial band autograft (50 × 15 mm)	Acetabular side: double loaded 2.9-mm biocomposite suture anchor Femoral side: 9 × 30-mm biocomposite interference screw and bone
O'Donnell et al.,[11] 2010	None—all concomitant surgeries were excluded	Drilling guide 2.3-mm guidewire Reamer 1 mm larger than the graft diameter Burr	Mid-trochanteric Posterior para-trochanteric Anterior para-trochanteric	Autologous semitendinosus tendons (5) and tibialis posterior allograft (4)—7-mm diameter	Acetabular side: two 2.3-mm hip anchors Femoral side: titanium inference screw
Rosinsky et al.,[9] 2020	Labral repair—9 (81.8%) Labral reconstruction—2 (18.2%) Capsular repair/plication —10 (90.9%) Capsular release—1 (9.1%) Acetabuloplasty—3 (27.3%) Femoroplasty—7 (63.6%) Iliopsoas release—2 (18.2%)	Special aiming device 2.3-mm guidewire 3.2-mm drill Reamer based on graft size Burr	Anterolateral Modified anterior	Tibialis posterior tendon allograft double construct (8-9 mm)	Acetabular side: cortical button Femoral side: 28-mm polyetheretherketone interference screw

10 representing the most satisfied.[21] Studies' PROs are summarized in Table 6. The standard mean difference of mHHS and NAHS between studies is compared in Fig 2.

All studies included in the present review reported on mHHS. All studies found an increase in mHHS score pre- to postoperatively with magnitudes ranging from 25.7 to 35.2. Average postoperative mHHS ranged from 71.8 to 86.9. MCID and PASS for mHHS were calculated or were able to be calculated in all studies at minimum 1-year follow-up. Philippon et al.[21] reported on 4 cases; however, 1-year outcomes were not available for one of these patients and preoperative mHHS scores were unavailable for another patient. Thus, of the eligible patients, only 1 of the 3 achieved PASS and 1 of 2 achieved MCID.[21] In addition, 8 of the 9 patients achieved PASS and all 9 patients achieved MCID for mHHS as reported by O'Donnell et al.[11] Rosinsky et al.[9] reported that at a minimum 2 years, 75% of their cohort achieved MCID. PASS was not recorded by Rosinsky et al.[9]

Secondary Operations and Complications

All 3 studies reported at least 1 patient requiring a secondary surgery and/or having postoperative complications. Philippon et al.[21] discussed 2 patients requiring revision surgery due to adhesions and impingement of the iliopsoas tendon at 6 months and 1 year, respectively. Additionally, one patient required a resurfacing arthroplasty at 15 months postsurgery due to persistent pain, although noted that instability was resolved. O'Donnell et al.[11] reported a third of their sample population requiring a revision arthroscopy due to recurrent and persistent symptoms. They also noted that postoperatively, one patient's graft was resorbed, and another patient obtained labial blisters due to traction pressure from surgery. The labial blisters were reported to have resolved within 4 weeks. Rosinsky et al.[9] reported that two cases converted to THA at a mean of 21.1 months due to persistent pain and radiographic findings of arthritis.

Discussion

This systematic review showed that LT reconstruction is mostly performed to address microinstability in the setting of a revision hip arthroscopy. Under these circumstances' patients have improved relative to their preoperative outcomes scores. However, despite this encouraging finding, a non-negligible reoperations rate of 33.3% was demonstrated throughout the 3 studies.

Considering the function of the LT, this study hypothesized that a major indication for LT reconstruction would be profound instability. Martin et al.[22] investigated the function of the LT in a cadaveric study. They assessed the effect of the LT in 18 distinct positions while preserving the joint capsule, thereby demonstrating added value

Table 5. Rehabilitation and Medications

Study	Weight-Bearing Protocol	Range of Motion Protocol	Medication
Philippon et al.,[21] 2012	Partial flat-foot weight-bearing for 2 weeks followed by full weight-bearing	Early passive motion starting the day of surgery to prevent adhesions Hip brace was issued to limit hip abduction, extension, and external rotation	Two weeks of indomethacin to prevent HO
Rosinsky et al.,[9] 2020	Restricted to 20 lbs. with crutched for first 6 weeks	Early movement used to avoid adhesions Hip brace was issued and flexion, abduction, adduction, and external rotation were limited	NSAIDS for 4 weeks for HO prophylaxis

HO, heterotopic ossification; NSAIDs, nonsteroidal anti-inflammatory drugs.

compared to previous studies where the joint capsule was removed. Martin et al.[22] demonstrated an increase in either internal or external rotation of the hip after resecting the LT. More than a 6° increase in rotation was observed in 11 of the 18 positions. Furthermore, the effect of the LT in limiting rotation was more evident when hips were flexed at 90° and 120°. The authors postulated that the LT stabilizes the hip joint in flexion since the iliofemoral ligament is lax in this position. Thus, the LT complements the function of the iliofemoral ligament rather than reinforcing it. The authors concluded that the major function of the LT is to control the rotation of the hip, mainly at 90° or greater of hip flexion.

Corroborating with Martin et al., all of the patients enrolled in the reviewed studies had findings indicating instability of the hip joint before their LT reconstruction. Patients included in all 3 studies had generalized ligamentous laxity, indicated by high Beighton scores, positive dial tests, and a positive radiographic axial traction test. In addition, Of the 24 patients included in the reviewed studies, 19 patients underwent LT reconstruction as a part of a revision procedure, while five patients underwent LT reconstruction during a primary hip arthroscopy. These results show that LT reconstruction is perceived as a procedure which is predominantly reserved for revision cases indicated for instability. Moreover, considering the prevalence of ligamentous laxity in the enrolled patients, stabilizing procedures (e.g., capsular plication) may not resolve the instability due to the compromised integrity of their soft tissues. However, due to the limited sample size and number of included studies, future studies may investigate the role of primary LT reconstruction in patients with profound ligamentous laxity.

The second aim of the current study was to investigate the outcomes for patients undergoing reconstruction of the LT. Maldonado et al.[23] compared PROs for patients with minimum 2-year follow-up who underwent primary hip arthroscopy. Patients with a concurrent FAI, labral tears, and complete LT tears were matched to a control group with intact LT. A 1:3 matching ratio resulted in 18 and 54 patients with complete LT tear and intact LT, respectively. Instability was controlled by matching for capsular treatment and radiographic CEA. Patients with complete LT tears demonstrated improvement in the majority of PROs; however, they were 3 times more likely to require THA compared with their matched control group. Corroborating with Maldonado et al., this study has demonstrated favorable results for patients who underwent LT reconstruction with the majority of patients reaching clinically meaningful outcomes. Considering that 70.8% of patients underwent hip arthroscopy procedures previously, the favorable PROs following the revision may confirm that LT reconstruction was rightfully indicated to address the refractory symptomatic hip instability.

Table 6. Average Patient-Reported Outcomes for Selected Studies

	mHHS			NAHS			iHOT-12			VAS			Satisfaction
Study	Preoperative	Latest	Delta	Preoperative	Latest	Delta	Preoperative	Latest	Delta	Preoperative	Latest	Delta	Latest (Range)
Philippon et al.,[21] 2012*	52.7	78.0	25.7	–	–	–	–	–	–	–	–	–	8 (6-9)
O'Donnell et al.,[11] 2020	51.7	86.9	35.2	–	–	–	–	–	–	–	–	–	–
Rosinsky et al.,[9] 2020	44.1	71.8	27.7	47.5	78.6	31.1	–	61.0	–	7.8	3.6	−4.2	7.9 (4-10)

iHOT-12, international Hip Outcome Tool; mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score; VAS, visual analog scale.
*Scores only available for 3 of 4 patients.

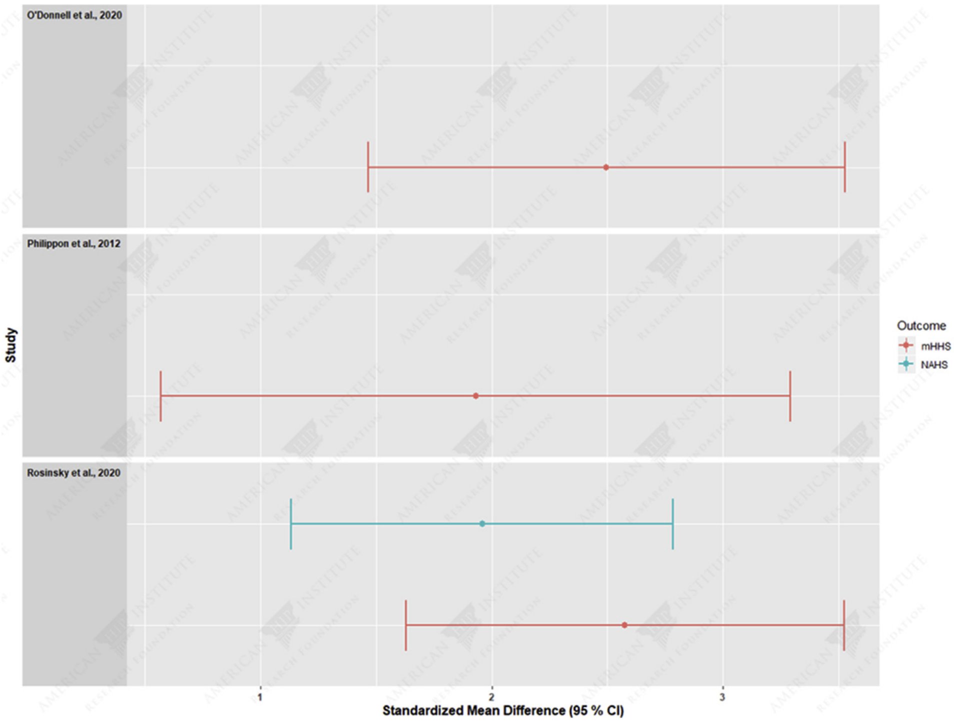

Fig 2. Standard mean difference of patient-reported outcomes. (CI, confidence interval; mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score.)

All 3 studies reported on complications and secondary surgeries following the LT reconstruction. Minkara et al.[24] evaluated in their systematic review risks factors and outcomes after arthroscopic management of FAI. Of the 31 included studies, the authors reported a cumulative risk of reoperation after hip arthroscopy, either a revision or a conversion to THA, to be 5.5% (95% CI 3.6%-7.5%). Of the patients requiring a reoperation, 77% underwent a conversion to THA and 13% underwent a revision hip arthroscopy. Further, the reported complications risk was 1.7% (95% CI 0.9%-2.5%). The most frequent complication was heterotopic ossification, following by transient neuropraxia. In this systematic review, eight patients (33.3%) in total underwent a secondary surgery, of which 5 patients (62.5%) underwent a revision hip arthroscopy due to recurrence or persistent symptoms, adhesions, and iliopsoas impingement. The other 3 patients (37.5%) underwent hip arthroplasty (either THA or resurfacing). The relatively high rate of secondary procedures compared to the rate reported by Minkara et al., may be the result of the following factors; First, most of the enrolled patients underwent a previous hip arthroscopy, indicating more complex cases and possibly accumulative intra-articular damage. Second, the relatively scarce evidence of LT reconstruction in the literature may indicate an ongoing learning curve of the procedure. Third, the relatively low numbers of included studies and enrolled patients may impair the generalization of the results, including the demographics of secondary procedures and complications. Moreover, the nature of the postoperative sequelae emphasizes the importance of proper patient selection and precautions related to prolonged traction. Finally, reviewing the limited literature on this subject may emphasize the significance of the LT as a stabilizer of the hip joint and possibly encourage surgeons to include LT reconstruction in their joint stabilizing surgical arsenal.

Limitations

The first limitation of this study is a relatively small number of included studies, which together with a relatively low level of evidence and small number of enrolled patients may limit the generalization of this systematic review. These limitations reflect the low prevalence of surgeons performing this procedure. Second, the outcomes may be influenced by the concomitant procedures performed together with the reconstruction of the LT at the time of the arthroscopy (e.g., labral repair, femoroplasty).

Conclusions

Reconstruction of the LT may be considered in surgical management for patients with symptomatic hip instability due to soft-tissue causes. Current evidence supports for LT reconstruction predominantly for patients experiencing refractory instability following previous hip-preservation procedures. Patients' expectations as well as the relatively high reoperation rate (i.e., 33%) should be discussed before the procedure.

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Appendix
Table 1. Search Algorithm

PubMed

(((((reconstruction) OR repair) OR debridement)) AND ligamentum teres[Title]) AND hip

Embase

('ligament of head of femur'/exp OR 'femoral head ligament' OR 'femur head ligament' OR 'ligament of head of femur' OR 'ligamentum capitis femoris' OR 'ligamentum teres femoris' OR 'ligamentum teres of the femur' OR 'ligamentum teres of the head of the femur' OR 'ligamentum teres of the hip' OR 'round ligament of femur' OR 'round ligament of the femur' OR 'round ligament of the hip') AND ('therapy'/exp OR 'combination therapy' OR 'disease therapy' OR 'disease treatment' OR 'diseases treatment' OR 'disorder treatment' OR 'disorders treatment' OR 'efficacy, therapeutic' OR 'illness treatment' OR 'medical therapy' OR 'medical treatment' OR 'multiple therapy' OR 'polytherapy' OR 'somatotherapy' OR 'therapeutic action' OR 'therapeutic efficacy' OR 'therapeutic trial' OR 'therapeutic trials' OR 'therapeutics' OR 'therapy' OR 'therapy, medical' OR 'treatment effectiveness' OR 'treatment efficacy' OR 'treatment, medical')

Cochrane

("round ligament of femur" [MeSH Terms])