Original Article

Ligamentum Teres Lesions Are Associated With Poorer Patient Outcomes in a Large Primary Hip Arthroscopy Cohort of 1,935 Patients

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Purpose: To retrospectively evaluate the prevalence and characteristics of ligamentum teres (LT) lesions identified in a single-surgeon hip arthroscopy cohort and to compare surgical outcomes of those with, and without, identified LT lesions. **Methods:** Patients who underwent primary hip arthroscopy between 2005 and 2018 in one surgeon's clinic were identified. Those with a history involving extra-articular scoping or any previous surgery on the ipsilateral hip were excluded. Patient-reported outcome measures completed before and after surgery included the Hip Disability and Osteoarthritis Outcome Score, Nonarthritic Hip Score, and 12-item International Hip Outcome Tool. Conversion to hip joint replacement was ascertained through a national register. **Results:** A total of 1,935 primary hip arthroscopies (from 1,607 different patients) were included in this study. In total, 323 LT lesions were identified. Those with LT lesions were older than those without (40.3 ± 11.3 years compared with 33.9 ± 12.1 years; $P < .001$), and more frequently female (58.2% vs 41.8%; $P = .001$). Hips with lesions had a smaller lateral center-edge angle than other hips (33.0 ± 6.8° vs 34.1 ± 6.0°; $P = .004$). All patient-reported outcome measures improved significantly ($P < .001$) from pre- to post-surgery for patients with and without LT lesions. However, patients with LT lesions reported less improvement in the 12-item International Hip Outcome Tool (difference −5.60; $P = .004$) and in Hip Disability and Osteoarthritis Outcome Score symptoms (−4.41; $P = .004$), sports (−7.81; $P < .001$), and quality of life subscales (−8.85; $P < .001$) than those without lesions. Hips with LT lesions also had a 6.2% 2-year rate of subsequent hip replacement (20/323 hips) compared with those without lesions (0.9%; 14/1612 hips; $P < .001$). **Conclusions:** In this single-surgeon hip arthroscopy cohort, identification of LT lesions was associated with poorer patient-reported outcomes and increased likelihood of conversion to arthroplasty within 2 years. These findings suggest a poorer prognosis for patients with LT injury compared with those without. **Level of Evidence:** Level III, retrospective cohort study.

Hip arthroscopy is considered the gold standard for the diagnosis of lesions of the ligamentum teres (LT),[1] and LT pathologies have been reported more frequently in arthroscopy surgical literature in the past decade.[2-7] Such lesions can arise secondary to trauma, degeneration,[1-3] or impingement syndromes.[4-6] Lesions often are associated with other hip pathologies like femoroacetabular impingement (FAI)[1,7] and can occur with or without hip dislocation.[8,9] Lesions of the LT are reported to cause pain and instability and may predispose patients to chondrolabral or osteoarthritic changes in the joint.[10,11] In patients who undergo hip

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arthroscopy, they are associated with microinstability, a condition characterized by painful translational movement of the femoral head,[12] although it is not clear if lesions are a cause or result of microinstability.[13] Several surgical procedures have been described to treat the damaged LT, ranging from partial excision to replacement with artificial grafts.[14-22] Partial ligament tears are the most commonly reported lesions,[23-25] for which partial excisional debridement is the treatment of choice.[1,14,24,26,27]

Previous studies, conducted in the United States and Australia, have analyzed types of LT lesions, patient demographics, and treatment outcomes.[1,7,12,23-25,27,28] The majority of these studies are limited by small sample size, ranging from 4 to 30 participants,[1,24,25,27] or have investigated a specific type of ligament pathology.[24,27,28] Detailed data relating to LT pathology, patient demographics, evaluation and/or treatment with hip arthroscopy, and longer-term sequalae are reported less frequently. This information would be beneficial to ensure optimal patient outcomes and potentially inform surgical decision making.

The purpose of this study was to retrospectively evaluate the prevalence and characteristics of LT lesions identified in a single-surgeon hip arthroscopy cohort and to compare surgical outcomes of those with, and without, identified LT lesions. We hypothesized that LT lesions might be associated with differences in presurgical characteristics or arthroscopic outcomes.

Methods

Hip Arthroscopy Selection and Procedures

Patient data from a cohort of primary hip arthroscopies, undertaken between 2005 and 2018 by a single surgeon (M.J.B.) in private practice, were obtained for this study. Patients who had procedures involving extra-articular scoping or any previous surgery on the ipsilateral hip were excluded.

Arthroscopies were performed primarily to treat labral injuries or chondrolabral damage associated with FAI, with or without acute trauma, in the lateral decubitus position using a general surgical and rehabilitative approach previously described.[29] Visual inspection of the LT was made using a 70° portal. Treatment depended on the pathology encountered and included labral repair when there was sufficient-quality tissue, or autograft reconstruction with femoral osteoplasty (for offset <8 mm) or acetabular osteoplasty (for deep anterolateral socket) to correct cam or pincer morphology as identified by the dynamic impingement test. Treatment for full thickness chondral damage was with curettage and microfracture, with a tendency since 2012 to bevel the rim slightly, when acetabular depth allowed, to reduce the size of the lesion. Since 2010, the capsule has been repaired following capsulotomy, with plication employed when indicated by surgically confirmed hip laxity (microinstability diagnosis). Primary arthroscopic procedures, with and without LT lesions, are usually performed to treat chondrolabral damage associated with FAI, with or without acute trauma, and to perform corrective osteoplasty if indicated. They are broadly categorized by primary diagnosis as follows: cam-dominant FAI, pincer-dominant FAI, combined FAI, microinstability with or without FAI-related morphology, traumatic labral or chondral damage with no evidence of FAI or osteoplasty performed, and significant osteoarthritis revealed during surgery without osteoplasty performed.

Relevant clinical information and patient-reported outcome measures (PROMs) data were collected prospectively with individual informed consent using an ethically approved data acquisition process; ethical approval for secondary analysis also was obtained. From primary arthroscopies, we identified those in which any LT lesion diagnosed during surgery was reported, and compared this subgroup with remaining hip arthroscopies that did not have an identified LT lesion. Additional data relating to health, lifestyle, LT pathology, and treatment were obtained and reported only for the subgroup with LT lesions. The study was approved by the New Zealand Health and Disability Ethics Committee (17/NTA/269) and approval for this secondary analysis was granted from the Human Ethics Committee (Health), University of Otago (HD17/032).

Patient Demographics and Clinical Presentation

Demographic, basic clinical, imaging, and surgical variables were available for secondary analysis from the surgeon's prospectively collected dataset. Lateral center-edge angle (LCEA) had previously been measured from preoperative radiographs by the surgeon.[30] Additional variables were extracted from clinical records only for the subset of arthroscopies with LT lesions. These included onset (gradual or sudden) and duration of hip symptoms, the cause and mechanism of traumatic injuries, patient-reported symptoms, and clinical signs.

Pathology and Management of LT Lesions

LT lesions were classified as complete tears, partial tears, and degenerative changes based on the classification system proposed by Gray and Villar.[26] A complete LT rupture was defined as a lack of anatomical continuity of the ligament, and a partial tear was diagnosed if the fibers were still attached between the articular insertions (Fig 1). Degenerative lesions, commonly associated with hip osteoarthritis, were identified by the "ragged" appearance of the entire LT. In addition to these major pathologies, the presence of generalized inflammation resulting in a red-colored, inflamed ligament was considered as synovitis, enlargement without visible inflammation as

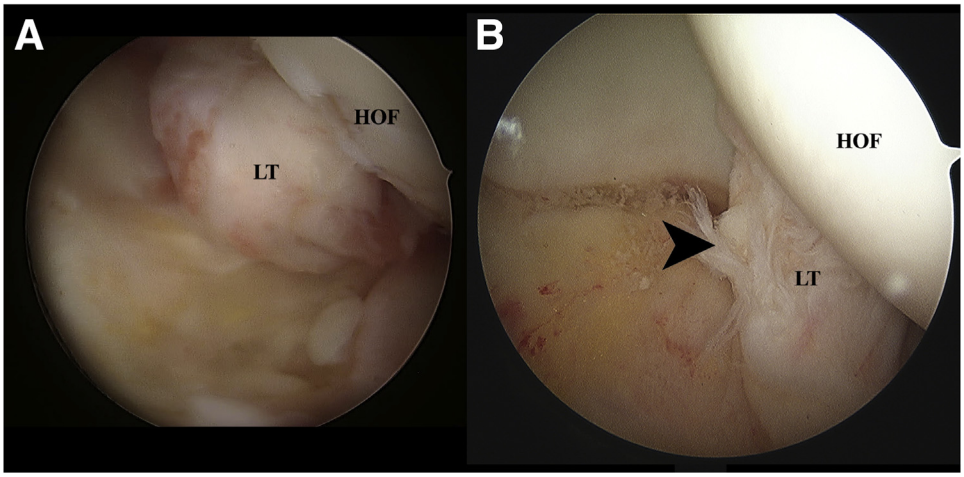

Fig 1. Arthroscopic appearance of right hip joints showing (A) normal and (B) partially torn LT viewed through a 70° portal. Fraying of the torn ligament fibers are visible in (B) (arrowhead). (HOF, head of femur; LT, ligamentum teres.)

hypertrophy, and a central tear classed as a cyclops lesion. Surgical management of LT lesions depended on the condition of the ligament tissue. Unstable fronds of tissue were excised, but superficial or stable lesions did not receive surgical intervention.

Surgical and Patient-Reported Outcomes

Outcomes of arthroscopic surgery were obtained from records of subsequent ipsilateral hip surgery and PROMs. Dates of any subsequent revision or reoperative procedures were obtained from the surgeon's database or clinical notes and subsequent hip joint replacements identified from the New Zealand Orthopaedic Association Joint Registry. Rates of revision or reoperative surgery or conversion to total hip arthroplasty, expressed as a proportion of all primary arthroscopic surgeries, were compared for those with, and without, LT lesions identified in their primary arthroscopic procedure.

PROMs were obtained before, and at regular intervals following primary arthroscopy. These included subscales of the Hip Disability and Osteoarthritis Outcome Score (HOOS),[31] total scores of Nonarthritic Hip Score tool,[32] and the 12-item International Hip Outcome Tool (iHOT-12).[33,34] Two-year follow-up scores were used when available, but when unavailable later follow-up responses were substituted (e.g., 3- or 5-year scores). When no later scores were available, data from 1-year follow up were used. Improvements in outcomes were compared for those with, and without, LT injuries. The proportion of surgeries attaining minimum clinically important differences (MCIDs) also were calculated. Two sources of MCIDs were used: (1) those values that had previously been reported from similar clinical settings[35,36]; and (2) values calculated for each outcome measure as half the standard deviation of preoperative scores for all hip arthroscopies according to the rationale and method of Norman et al.[37]

Statistical Analyses

Data for descriptive statistics (e.g., age, body mass index [BMI] are expressed as mean ± standard deviation). Differences according to demographic, clinical and surgical variables, between those with, and without, LT lesions, and according to type of LT lesion were determined using χ^2 tests for categorical independent variables and unpaired *t* tests for 2 categories, or analyses of variance models for more than 2 categories of continuous variables.

Differences between patients with, and without, LT lesions in pre- to post-operative changes in PROMs were established using repeated measures analyses of variance. For all calculations, a P value of $< .05$ was considered statistically significant. Changes in PROMs were also compared between sex and according to whether surgical treatment of LT was undertaken.

Results

Characteristics of Hip Arthroscopies

From a total of 2,147 hip arthroscopies performed during the period from June 2005 to December 2018, 205 secondary hip surgical procedures (revisions and reoperations of both the surgeon's own patients and from other surgeons) were eliminated. From the remaining 1,942 arthroscopies, a further 7 atypical arthroscopies entailing neither osteoplasty nor chondrolabral repair were excluded from analysis: 3 for acute intra-articular fracture or dislocation, 1 for villonodular synovitis, 1 for adhesive capsulitis, 1 for chondrocalcinosis, and 1 for snapping iliopsoas. Thus, a total of 1,935 primary hip arthroscopies (from 1,607 different patients) are included in this study.

There was a steady increase in the number of primary arthroscopies undertaken over the time period: 3 to 6 per year from 2005 to 2007, to between 198 and 251

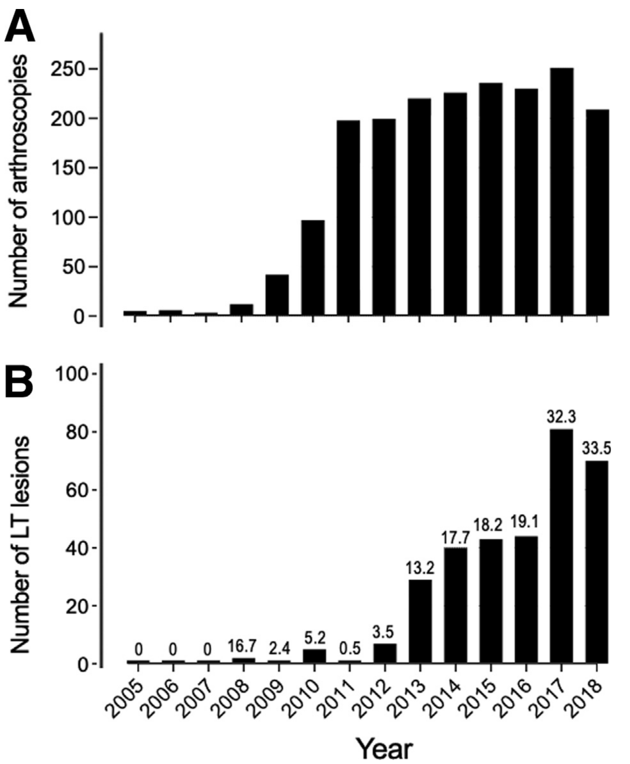

Fig 2. (A) The number of primary hip arthroscopies performed per year (n = 1,935) and (B) number of arthroscopies with an identified LT lesion (n = 323). In (B) the percentage of arthroscopies with a LT lesion for each year is shown above each bar. (LT, ligamentum teres.)

per year after 2010 (Fig 2A). Numbers according to primary diagnostic category were cam-dominant FAI (639, 33%); pincer-dominant FAI (147, 7.6%); combined FAI (309, 16%); microinstability (148, 7.6%); traumatic labral or chondral damage without FAI (685, 35%); and significant osteoarthritis (7, 0.4%). Approximately two-thirds of the surgeries were covered by private health insurance (61.9%) or were self-funded 7.1%); one-third were by publicly-funded insurance (28.5%) (New Zealand Accident Compensation Corporation, which covers only surgery for injury deemed as resulting from an acute accident) or a charity organization (2.3%).

Patient age at the time of hip arthroscopy ranged from 12.0 to 70.7 years (mean ± standard deviation; 35.0 ± 12.2 years), with almost equal numbers of female (n = 967) and male (n = 968) patients. More arthroscopies were performed on right (54.4%) than left hips (45.6%; P < .001). The LCEA, available for 1897 arthroscopies (98%), ranged from 11° to 57° (33.9 ± 6.1°) and was slightly greater in male than female patients (34.3 ± 6.0° vs 33.4 ± 6.2°; P = .001) and in left compared with right hips (34.3 ± 6.1° vs 33.5 ± 6.1°; P = .002). BMI, available for 1,048 arthroscopies (54.2%), was 25.3 ± 4.2.

Prevalence and Demographics of LT Lesions

Within the study period, LT lesions were identified in 323 primary arthroscopies (16.7% of all 1935 arthroscopies) in 302 different patients, the first being in 2008. From 2013, both the annual number and proportion of total primary hip arthroscopies with identified LT lesions increased markedly over time (P < .001, Fig 2B).

The age of the patients with LT lesions ranged from 13.8 to 67.6 (40.2 ± 11.5) years, with the largest number identified in patients aged 40 to 49 years (Fig 3). Patients with LT lesions were older (40.3 ± 11.3 years) than those without (33.9 ± 12.1 years; P < .001). As a proportion of primary hip arthroscopies, LT lesions were most commonly identified in the 50- to 59-year group (Fig 3). More LT lesions were recorded in female (188/323; 58.2%) than male (135/323; 41.8%) patients; 19.4% of female compared with 13.9% of male patients who underwent arthroscopy had these lesions identified (P = .001, Fig 3). There was no difference in BMI between patients with and without LT lesions.

Presurgery Imaging and Clinical Presentation of LT Lesions

Patients with LT lesions had a smaller LCEA than those without lesions (33.0 ± 6.8° vs 34.1 ± 6.0°; P = .004). For those with LT lesions, the angle was smaller in female (31.9 ± 6.4) than male (34.4 ± 7.0; P < .001) patients and in right (32.2 ± 6.4) compared with left hips (33.9 ± 7.1; P = .03).

Almost all the 323 patients with LT lesions had an active lifestyle or physically demanding job, apart from 10 who were sedentary and had desk jobs. Most (229, 79%) of these patients reported a sudden rather than gradual onset of symptoms, which ranged in duration before surgery from 7 months to 16 years and 2 months

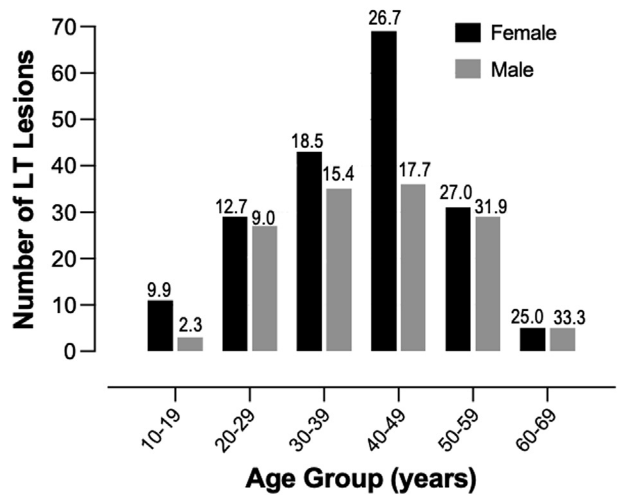

Fig 3. Distribution of LT lesions between different age groups for female (black) and male (gray) patients. The percentage of arthroscopies with an identified LT lesion (n = 323) is shown above the bars for each sex and age group. (LT, ligamentum teres.)

(2.2 ± 2.3 years). Almost two-thirds of sudden-onset symptoms were attributed to involvement in sports (145, 63%), the most common being gym or fitness activities including yoga (27), running (24), and rugby (14), followed by household or workplace injuries (72, 31%). The injury mechanism was documented for most sudden-onset cases (n = 181, 79%). Falls, splits, and twists were commonly reported, combined with abduction, hyperflexion, and rotation of the hip; no adduction injuries were reported.

Nonspecific symptoms reported included groin pain (n = 194, 60%), or pain felt on the lateral side of the hip and the buttock region, as per the classic C-sign (n = 51, 16%); 40 (12%) patients complained of a clicking or catching sensation. Symptoms were commonly exacerbated when walking upstairs or uphill and on uneven ground, or with turning, twisting or prolonged standing and weight-bearing. Pain was also commonly felt during movements involving hip flexion (squatting, lunging or crouching). Pain from prolonged sitting was often relieved by standing or walking.

On examination, most cases demonstrated a positive quadrant test (n = 257, 80%), and a painful or restricted flexion−abduction−external rotation (FABER) sign (n = 188, 58%) that reproduced pain, at least at the end range of movement. Some patients reported pain in forced- or hyper-flexion and there was often reduced range of motion, typically in internal rotation. Limping was rarely noticed, except for 20 patients who presented with an antalgic gait pattern.

Surgically Identified Pathology of LT Lesions

A wide range in the degree and nature of LT pathology was observed, from mild synovitis to complete tears, the most prevalent being isolated degenerative lesions (185/323 lesions: 57%), followed by partial tears (74/323: 23%) (Table 1). LT lesions were identified across a range of surgery categories, with a greater proportion of lesions evident in total arthroscopies for microinstability ($P < .001$ for overall χ^2 analysis; Table 1). Those with nondegenerative partial or full tears/ruptures compared with those with degenerative lesions without tears were younger (37.8 ± 11.9 years vs 41.6 ± 11.0 years; $P = .01$) and disproportionately female when taking the greater overall proportion of lesions in female patients into account (62/87, 71% of tears were in female patients, whereas 99/195, 51% of degenerative lesions were in male patients; $P < .001$ for χ^2 analysis).

Surgical Treatment

In the majority of cases no treatment to the LT was deemed necessary (238/323 cases, 74%). Surgical treatment (85/323, 26%) entailed partial excision of the damaged ligament, with synovectomy in 2 cases, except for one case which was treated with synovectomy only. Excision was performed for over half of nondegenerative partial/full ruptures (49/87, 56%), including in four of five complete ruptures, but in less than one-tenth of non-torn degenerative lesions (18/195, 9.2%).

Surgical Outcomes

Of the 1,935 total primary arthroscopies, a total of 141 (7.3%) had subsequent revision or reoperative surgery and 66 (3.4%) underwent subsequent conversion to hip joint replacement before July 2020, after 5.8 ± 2.6 years' follow-up. Because the average follow-up time was almost 2 years shorter for arthroscopies with LT lesions than other arthroscopies (4.2 ± 2.0 years compared with 6.1 ± 2.6 years, $P < .001$; Table 2), rates of subsequent surgery within 2 years were compared, noting that 100 surgeries (5.2%) had not yet reached 2 years. Whilst a similar rate of subsequent revisions or reoperations within 2 years was observed for patients with LT lesion (n = 6/323 hips, 1.9%) compared with those without (n = 38/1612 hips, 2.4%; $P = .6$, the rate of conversion to total hip joint replacement within 2 years was more than 7 times greater for patients with a LT lesion (20/323 hips, 6.2%) compared with those without (14/1612 hips, 0.9%; $P < .001$) (Table 2). For those who had subsequent conversion, the duration from surgery to hip replacement was also shorter for those with LT lesion than those without (1.8 ± 1.8 years vs 3.0 ± 2.2 years; $P = .02$).

Patient-Reported Outcomes

Approximately one-half of patients who had an arthroscopy had 2-year follow-up scores available (52% for the 323 arthroscopies with LT lesions; 46% overall). Inclusion of later follow-up (2-year minimum) increased response rate to 63%, and including 1-year follow-up, when later follow-up was missing, increased this response rate to 78% (for arthroscopies with LT lesions and overall). Approximately two-thirds of surgeries (71% for arthroscopies with LT lesions, and 64% overall) had both preoperative and 1-year minimum postoperative scores available for analysis in repeated-measures analysis of variance. PROMS improved significantly ($P < .001$) from pre- to post-surgery, for patients with, and without, LT lesions (Table 3). However, improvement was greater for those without LT pathology compared with those with LT pathology for iHOT-12 and HOOS−symptoms, −sports and −quality of life subscale scores (Table 3). For those with LT lesions, there was no difference in improvement in any outcome measures between those who had LT surgical intervention and those who did not.

Sizeable proportions of patients did not have difficulties with daily activities and scored PROMs highly before surgery. Three PROMs had low proportions (< 10%) of high preoperative scores: iHOT-12 and HOOS−sports and −quality of life, for which only 2%, 7%, and 1% of scores, respectively, scored 80% or

Table 1. Number of Cases for Different Pathologies of LT Lesions According to Category of Arthroscopy by Primary Diagnosis

	Arthroscopy Type						
LT Pathology	Cam-Dominant FAI	Pincer-Dominant FAI	Combined FAI	Microinstability	Chondrolabral Repair	Osteoarthritis	Total
Degenerative	77	13	25	21	47	2	185
Partial tear	15	3	4	16	36	Nil	74
Partial tear + degenerative	6	1	2	3	7	Nil	19
Hypertrophy	3	Nil	1	3	6	Nil	13
Complete rupture	1	Nil	Nil	3	1	Nil	5
Degenerative + hypertrophy	1	Nil	Nil	2	4	Nil	7
Synovitis	1	Nil	1	1	Nil	Nil	3
Degenerative + synovitis	3	Nil	Nil	Nil	Nil	Nil	3
Partial tear + hypertrophy	1	Nil	Nil	3	Nil	Nil	4
Hypertrophy + synovitis	Nil	Nil	Nil	1	1	Nil	2
Partial tear + degenerative + hypertrophy	1	Nil	Nil	Nil	1	Nil	2
Partial tear + degenerative + synovitis	2	Nil	Nil	Nil	Nil	Nil	2
Ruptured + degenerative	Nil	Nil	Nil	1	1	Nil	2
Partial tear + synovitis	Nil	Nil	Nil	Nil	1	Nil	1
Cyclops lesion	Nil	Nil	Nil	1	Nil	Nil	1
Total lesions (% of total arthroscopies)	111 (17.4)	17 (11.6)	33 (10.7)	55 (37.2)	105 (45.5)	2 (28.6)	323 (16.7)
Total arthroscopies	639	147	309	148	685	7	1935

FAI, femoroacetabular impingement; LT, ligamentum teres.

greater. Using previously published values for minimal detectable change 95% confidence interval for HOOS—sports and —quality of life[35] and MCID for iHOT-12,[36] 54.4%, 75.1%, and 78.2% of patients, respectively, reported a change of at least these thresholds at 1-year minimum follow-up. The use of MCIDs calculated from our own data according to the method of Norman et al.[37] resulted in greater percentages of patients who attained them: 79.2%, 81.3%, and 82.7% for HOOS—sports, HOOS—quality of life, and iHOT-12, respectively (Table 4). For all 3 PROMs, lower proportions of patients with LT lesions reported improvements meeting these clinical thresholds than those without ($P \leq .002$; Table 4).

An analysis of PROMs from arthroscopies with an identified LT lesion showed that females improved more than males across all outcome measures ($P \leq .003$). Presurgery scores were lower in female than male patients, whereas there was no significant difference in postoperative outcome scores between the sexes (Table 5). No differences in improvement of PROMs related to surgery side were identified (data not shown).

Discussion

The most important finding of this observational study of primary hip arthroscopies is that patients with surgically identified LT lesions were more than 7 times more likely to require conversion to total hip joint replacement within 2 years of surgery, compared with those without LT lesions. Furthermore, slightly less improvement in PROMs, particularly for sports activity and quality of life, and greater likelihood of attaining

Table 2. Surgical Outcomes Following Primary Hip Arthroscopy for Patients With and Without LT Lesions

	LT Lesions (n = 323)	Other Primary Arthroscopies (N = 1612)	Statistical Significance (*P*)
Follow-up time, y	4.19 ± 1.99	6.12 ± 2.63	<.001
Revision/reoperation	13 (4.0%)	128 (7.9%)	.01
Revision/reoperation within 2 y	6 (1.9%)	38 (2.4%)	.58
Time to revision/reoperation, y*	2.12 ±1.30	3.05 ± 1.73	.06
Total hip joint replacement	29 (9.0%)	37 (2.3%)	<.001
Total hip joint replacement within 2 y	20 (6.2%)	14 (0.9%)	<.001
Time to total hip joint replacement, y*	1.79 ± 1.80	2.98 ± 2.21	.02

NOTE. Data are number (percentage) for frequency variables or mean ± SD for continuous variables. Statistical significance represented as *P* values are for χ^2 analysis for frequency data and *t*-tests for continuous data.

LT, ligamentum teres; SD, standard deviation.

*Duration from primary hip arthroscopy to revision/reoperation or total hip joint replacement for those patients who had the respective subsequent surgery.

Table 3. Pre- and Post-Operative Patient-Reported Outcomes for Primary Arthroscopies With Surgically Confirmed LT Lesions Compared With Those With No LT Lesion

	LT Lesions			Other Primary Arthroscopies			Difference in Change From Pre- to Postsurgery*	
	n	Pre-	Post-	n	Pre-	Post-	Mean (95% CI)	*P*†
NAHS total	230	60.7 ± 17.9	82.2 ± 15.8	1,017	60.9 ± 17.5	84.9 ± 15.3	−2.52 (−5.3 to 0.2)	.07
iHOT-12	232	39.5 ± 20.5	70.7 ± 24.1	871	37.1 ± 18.5	74.0 ± 24.0	−5.60 (−9.4 to −1.8)	.004
HOOS−symptoms	239	58.4 ± 19.6	75.6 ± 18.4	993	57.1 ± 19.2	78.7 ± 17.6	−4.41 (−7.5 to −1.4)	.004
HOOS−pain	238	59.7 ± 19.0	81.1 ± 17.5	991	59.5 ± 19.0	83.7 ± 16.8	−2.84 (−5.8 to 0.1)	.06
HOOS−activities of daily living	238	68.4 ± 21.3	87.3 ± 16.6	993	68.2 ± 20.0	89.3 ± 15.1	−2.16 (−5.0 to 0.7)	.14
HOOS−sports	233	47.0 ± 23.9	72.0 ± 22.1	987	44.5 ± 22.8	77.3 ± 22.0	−7.81 (−11.7 to −3.9)	<.001
HOOS−quality of life	239	36.4 ± 21.2	62.9 ± 22.0	992	32.4 ± 18.3	67.8 ± 23.5	−8.85 (−12.5 to −5.1)	<.001

NOTE. Data are mean ± SD unless otherwise stated.

CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; iHOT-12, 12-item International Hip Outcome Tool; LT, ligamentum teres; NAHS, Nonarthritic Hip Score; SD, standard deviation.

*Expressed as change in those with ligamentum teres lesion minus change in other primary hip arthroscopies, i.e., reduced increase in score

†*P* value for interaction of LT lesion status from pre- to postsurgery.

Minimal Detectable Change at 95% Confidence/MCID thresholds, were reported in patients with LT lesions compared with those without. Patients with LT lesions were also more likely to be female and have a smaller LCEA.

This study is a large, single-surgeon series of hip arthroscopy (1,935 patients) describing 323 cases with LT lesions. Although all the patients were from one private sports clinic, the advantage is that the surgical management of primary hip arthroscopies is more consistent than a multicenter study. Therefore, the comparisons reported between patients with, and without, LT pathology provide stronger internal validity.

The increasing prevalence, in recent years, of LT lesions identified during arthroscopic surgery may be due to the increased recognition of LT pathology by the surgeon as a result of increased awareness of the clinical importance of this structure in relation to hip stability.[7,12,13,23,24,38,39] LT lesions, particularly degenerative lesions, were more prevalent in older age-groups, which may reflect aging processes or age-related changes in lifestyle or participation in sports.

A smaller LCEA has been suggested to be a risk factor for LT injuries.[7] Here, we also observed a smaller LCEA angle in hips with LT lesions compared with those without. This variation in acetabular morphology (shallow socket) could result in increased translational movement of the femoral head, leading to partial LT rupture, which has been previously reported in hips with smaller center-edge angle.[7,12,40]

Our findings agree with previous studies that report LT pathology as more common in female than male patients.[1,7,12,23-25,27,28] This has previously been suggested to be an incidental finding from a greater number of female patients presenting for hip arthroscopy for labral injuries,[28] which are more commonly reported in female patients.[41-45] However, in this study we report almost equal numbers of male and female patients undergoing hip arthroscopy. The sex-related difference in LT lesions noted here could be associated with a lower mean LCEA in female compared with male patients, or due to differences in lifestyle or sports participation.

Because LT lesions were identified less frequently in earlier years, the average follow-up time for hips with LT lesions was 2 years shorter than for other hip arthroscopies. It is therefore not surprising that the overall revision rate was also less in hips with LT lesions. Rates of subsequent surgery, including revisions and total hip arthroplasty within a 2-year period were therefore compared. With this unbiased comparison, there was no difference in revision rate between hips with, and without, LT lesions. The New Zealand Joint Registry, accessed to calculate hip arthroplasty rates following hip arthroscopy, is likely to be almost complete, since very few patients in this country have hip-replacement surgery undertaken abroad. The reasons

Table 4. Proportion (%) of Patients With Available PROMs Scores Attaining Minimal Clinically Important Difference (MCID) or Minimal Detectable Change at 95% Confidence (MDC95) Thresholds at 1-Year Minimum Follow-Up According to LT Lesion Status

	MCID/MDC95	LT Lesions	Other Primary Arthroscopies	*P* (Difference)
iHOT-12	13.9[36]	70.8	80.1	.002
	9.5*	75.9	84.5	.002
HOOS−sports	29.4[35]	44.3	56.7	<.001
	11.5*	70.4	81.3	<.001
HOOS−quality of life	16.4[35]	63.1	78.0	<.001
	9.5*	71.5	83.7	<.001

HOOS, Hip Disability and Osteoarthritis Outcome Score; iHOT-12, 12-item International Hip Outcome Tool; LT, ligamentum teres; PROM, patient-reported outcome measure.

*Calculated as 0.5× preoperative standard deviation of outcome measure for all hip arthroscopies, according to the rationale and method of Norman et al.[37]

Table 5. Pre- and Post-Operative Patient-Reported Outcomes for Primary Arthroscopies With Surgically Confirmed LT Lesions (n = 323) According to Sex

	Female (n = 188)		Male (n = 135)		Difference in Change From Pre- to Postsurgery*	
	Pre-	Post-	Pre-	Post-	Mean (95% CI)	*P*†
NAH total	57.0 ± 16.9	82.1 ± 15.2	66.1 ± 18.0	82.4 ± 16.8	8.79 (3.5- 14.0)	.001
iHOT-12	33.5 ± 18.4	70.7 ± 23.6	47.8 ± 20.4	70.8 ± 24.8	14.24 (7.5- 21.0)	<.001
HOOS−symptoms	55.6 ± 19.7	76.5 ± 16.1	62.3 ± 18.9	74.2 ± 21.3	9.02 (3.2- 14.8)	.002
HOOS−pain	56.2 ± 18.2	81.5 ± 15.9	64.6 ± 19.1	80.6 ± 19.5	9.17 (3.6- 14.7)	.001
HOOS−activities of daily living	65.6 ± 20.8	88.7 ± 14.1	72.4 ± 21.5	85.5 ± 19.5	10.04 (4.4- 15.7)	<.001
HOOS−sports	42.3 ± 23.1	72.0 ± 21.4	53.6 ± 23.4	72.1 ± 23.1	11.19 (4.0- 18.4)	.003
HOOS−quality of life	32.0 ± 19.4	63.8 ± 21.1	42.5 ± 22.1	61.7 ± 23.3	12.58 (5.8- 19.4)	<.001

NOTE. Data are mean ± SD unless otherwise stated.

CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; iHOT-12, 12-item International Hip Outcome Tool; LT, ligamentum teres; NAH, Nonarthritic Hip Score; SD, standard deviation.

*Difference is change in females minus change in males, i.e., additional increase in score

†*P* values are for interactions of sex pre- to postsurgery.

for greater risk of conversion to arthroplasty in the arthroscopy patients with LT lesions in this cohort are not clear, but this may be due to a more unstable joint that precipitates osteoarthritic changes through increased mechanical abrasion.[10-12] It is not possible to tell whether instability is the cause or a result of injury to the LT,[13] but a greater degree of preinjury instability is supported by the association of LT lesions with surgical diagnosis of microinstability and lower LCEA than hips without these lesions.[7,12,16]

In contrast to previous studies, we retrospectively reviewed clinically relevant variables, such as the onset and mechanism of injury and the cause and duration of symptoms, which were documented in clinical referrals and initial consultation letters. Most previous studies have not reported this information because patients could not recall the onset of symptoms following previous conservative treatment by general practitioners and physiotherapists.[23,28] While various movements were described in acute traumatic injuries, we could not identify a consistent mechanism of injury in the LT tear group, in particular adduction injury, a position in which the ligament is reportedly tensed.[46]

Significant improvements in all PROM scores were demonstrated in hip arthroscopy patients with, and without, LT lesions, which is similar to previous reports.[1,7,23,24,27,28] For patients with identified LT lesions, improvement from pre- to postoperative scores was evident both in those who had surgical treatment of the LT and those who did not. In patients who did not undergo surgical treatment, it is possible that the ligament healed itself,[47-49] the symptoms resolved spontaneously after healing of the accompanying lesions, or symptoms were not related to the LT lesion specifically.

Despite the observation that individuals with LT lesions showed improvement irrespective of the surgical procedure, the overall prognosis, especially for sport-related activities and quality of life, was worse than for those without such lesions. This poorer prognosis for these PROMs was noted both when average changes were compared and also when comparing proportions of patients attaining MCID. Only 3 PROM scores did not display ceiling effects at baseline, and therefore the proportions of patients attaining minimally important changes were calculated only for these measures. Use of the 0.5× baseline standard deviation method of Norman et al.[37] also allowed us to obtain estimates of MCID specific to this setting.

The poorer prognosis associated with hips with LT lesions may reflect the detrimental causes or consequences such as microinstability and early arthritic changes of the hip joint.[10,11,50] It is also possible that LT injury is associated with a greater degree of trauma, although this could not be quantified here. More frequent or severe subluxation injury would be consistent with our observation of slightly shallower and potentially less stable sockets in those with LT lesions compared to without. More significant subluxation trauma would be more likely to acutely tear LT, increasing instability further. Such trauma also would be associated with acute chondral injury and could predispose to chronic degenerative changes in articular cartilage. This degeneration could explain the increased rate of hip-replacement surgeries following arthroscopy in those with identified LT lesions.

Limitations

This study was undertaken in a cohort of patients from a single private sports clinic, and therefore its external validity may be compromised, as it may not be representative of a broader population of primary hip arthroscopies. Data were analyzed retrospectively from a surgical database not specifically designed for this study. Data are collected routinely in conjunction with clinical practice, and this could contribute to incomplete data in several fields, especially during the early years of data collection. Three different PROMs (HOOS, Non-arthritic Hip Score, and iHOT-12) were used to evaluate patient outcome according to their availability, for example, the iHOT-12 score, despite being more clinically relevant to assess young and active patients,[33,34] was available only after 2012.

A major limitation is that our study did not document the preoperative status of the joint cartilage or labrum, factors that could potentially mediate the poorer surgical or patient-reported outcomes noted for those with LT lesions following surgery. Another confounder in comparing surgical and patient-reported outcomes between those with and without LT lesions is patient age, which was significantly greater in patients with LT lesions.

Finally, changes in the surgeon's own practices and techniques over time may bias comparisons between those with, and without, LT lesions, since lesions were more commonly identified in more recent years.

Conclusions

In this single-surgeon hip arthroscopy cohort, identification of LT lesions was associated with poorer patient-reported outcomes and increased likelihood of conversion to arthroplasty within 2 years. These findings suggest a poorer prognosis for patients with LT injury compared with those without.

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