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.
arthroscopy, they are associated with microinstability, a
condition characterized by painful translational move-
ment 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 path-
ology.24,27,28 Detailed data relating to LT pathology,
patient demographics, evaluation and/or treatment
with hip arthroscopy, and longer-term sequelae 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 presur-
gical characteristics or arthroscopic outcomes.

Methods

Hip Arthroscopy Selection and Procedures

Patient data from a cohort of primary hip arthros-
copies, 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 lab-
r al injuries or chondrolabral damage associated with
FAI, with or without acute trauma, in the lateral decu-
bitus position using a general surgical and rehabili-
tative 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 (micro-
instability 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 pro-
spectively 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 re-
ported, 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 in-
juries, 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 classifi-
cation system proposed by Gray and Villar.26 A com-
plete 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
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), total scores of Nonarthritic Hip Score tool, and the 12-item International Hip Outcome Tool (iHOT-12). 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; 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.

**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 \( \chi^2 \) 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
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 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.)
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, 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 quadratus 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 χ² 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 χ² 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—symptoms, —sports and —quality of life, for which only 2%, 7%, and 1% of scores, respectively, scored 80% or
greater. Using previously published values for minimal detectable change 95% confidence interval for HOOS—sports and —quality of life and MCID for iHOT-12, 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. 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 ≤ .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 ≤ .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 1. Number of Cases for Different Pathologies of LT Lesions According to Category of Arthroscopy by Primary Diagnosis

| 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                 |             | 3               | 1                   | Nil           | 5     |
| Degenerative + hypertrophy | 1            | Nil                 | 1            | 3               | 6                   | Nil           | 1     |
| Synovitis | 1               | Nil                 | 1            | 1               | Nil                 | Nil           | 3     |
| Degenerative + synovitis | 3            | Nil                 | Nil          | Nil             | Nil                 | Nil           | 3     |
| Partial tear + hypertrophy | 1            | Nil                 | Nil          | Nil             | Nil                 | Nil           | 4     |
| Hypertrophy + synovitis | Nil         | Nil                 | Nil          | 1               | 1                   | Nil           | 2     |
| Partial tear + degenerative + hypertrophy | 1         | Nil                 | Nil          | Nil             | Nil                 | 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          | 1               | 1                   | Nil           | 1     |
| Cyclops lesion | Nil          | Nil                 | Nil          | 1               | 1                   | 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.

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 χ² 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.
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.11,12,13,23,24,38,39 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.1,7,12,13,23-25,47,48 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 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<sup>a</sup> |
|------------------------|------------|-----------------------------|--------------------------------------------------------|
|                        | n          | Pre-                        | Post-                     | n          | Pre-                        | Post-                     | P (95% CI) |
| NAHS total             | 230        | 60.7 ± 17.9                 | 82.2 ± 15.8              | 1,017      | 60.9 ± 17.5                 | 84.9 ± 15.3              | 0.001      |
| iHOT-12                | 232        | 39.5 ± 20.5                 | 70.7 ± 24.1              | 871        | 37.1 ± 18.5                 | 74.0 ± 24.0              | <0.001     |
| HOOS—symptoms          | 239        | 58.4 ± 19.6                 | 75.6 ± 18.4              | 993        | 57.1 ± 19.2                 | 78.7 ± 17.6              | <0.001     |
| HOOS—pain              | 238        | 59.7 ± 19.0                 | 81.1 ± 17.5              | 991        | 59.5 ± 19.0                 | 83.7 ± 16.8              | <0.001     |
| HOOS—activities of daily living | 238 | 68.4 ± 21.3                 | 87.3 ± 16.6              | 993        | 68.2 ± 20.0                 | 89.3 ± 15.1              | <0.001     |
| HOOS—sports            | 233        | 47.0 ± 23.9                 | 72.0 ± 22.1              | 987        | 44.5 ± 22.8                 | 77.3 ± 22.0              | <0.001     |
| HOOS—quality of life   | 239        | 36.4 ± 21.2                 | 62.9 ± 22.0              | 992        | 32.4 ± 18.3                 | 67.8 ± 23.5              | <0.001     |

<sup>a</sup>Note. Data are mean ± SD unless otherwise stated.

### 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

|                        | LT Lesions | Other Primary Arthroscopies | P (Difference) |
|------------------------|------------|-----------------------------|----------------|
|                        | n          | Pre-MCID/MDC95              | Post-MCID/MDC95 |
| iHOT-12                | 13.9<sup>a</sup> | 70.8                         | 80.1            | 0.002         |
|                        | 9.5<sup>a</sup> | 75.9                         | 84.5            | 0.002         |
| HOOS—sports            | 29.4<sup>a</sup> | 44.3                         | 56.7            | <0.001        |
|                        | 11.5<sup>a</sup> | 70.4                         | 81.3            | <0.001        |
| HOOS—quality of life   | 16.4<sup>a</sup> | 63.1                         | 78.0            | <0.001        |
|                        | 9.5<sup>a</sup> | 71.5                         | 83.7            | <0.001        |

<sup>a</sup>Calculated as 0.5 × preoperative standard deviation of outcome measure for all hip arthroscopies, according to the rationale and method of Norman et al.47
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.\textsuperscript{10-12} It is not possible to tell whether instability is the cause or a result of injury to the LT,\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{46}

Significant improvements in all PROM scores were demonstrated in hip arthroscopy patients with, and without, LT lesions, which is similar to previous reports.\textsuperscript{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,\textsuperscript{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 x baseline standard deviation method of Norman et al.\textsuperscript{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.\textsuperscript{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

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**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) |
| NAH total              | 57.0 ± 16.9      | 82.1 ± 15.2   | 66.1 ± 18.0      | 82.4 ± 16.8   | 8.79 (3.5- 14.0) |
| iHOT-12                | 33.5 ± 18.4      | 70.7 ± 23.6   | 47.8 ± 20.4      | 70.8 ± 24.8   | 14.24 (7.5- 21.0) |
| HOOS-symptoms          | 55.6 ± 19.7      | 76.5 ± 16.1   | 62.3 ± 18.9      | 74.2 ± 21.3   | 9.02 (3.2- 14.8)  |
| HOOS-pain              | 56.2 ± 18.2      | 81.5 ± 15.9   | 64.6 ± 19.1      | 80.6 ± 19.5   | 9.17 (3.6- 14.7)  |
| HOOS-activities of daily living | 65.6 ± 20.8 | 87.8 ± 14.1   | 72.4 ± 21.5      | 85.5 ± 19.5   | 10.04 (4.4- 15.7) |
| HOOS-sports            | 42.3 ± 23.1      | 72.0 ± 21.4   | 53.6 ± 23.4      | 72.1 ± 23.1   | 11.19 (4.0- 18.4) |
| 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) |

**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.
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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