Tears of the Ligamentum Teres

Prevalence in Hip Arthroscopy Using 2 Classification Systems

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Background: The ligamentum teres (LT) anatomy has been known for many years. While its functionality remains debatable, it is well recognized that the LT can be a source of pain in the hip joint. In 1997, a landmark publication by Gray and Villar established a classification for LT tears and increased the awareness of LT disorders. However, the incidence of LT tears and the various tear types is unknown.

Purpose: The authors report the prevalence of LT tears in a population of patients who underwent hip arthroscopy, using both the Gray and Villar classification and a new descriptive classification.

Study Design: Case series; Level of evidence, 4.

Methods: Between February 2008 and January 2011, 616 hip arthroscopies were performed by the senior author. After excluding revision surgeries, a total of 558 surgeries (502 patients) were included in the study. Data were collected regarding patients' demographics, mechanism of injury, range of motion, magnetic resonance results, and intraoperative findings. Preoperative hip-specific questionnaire scores and pain level were recorded as well. Ligamentum teres tears were classified according to Gray and Villar's classification, and were also categorized using a descriptive grading system as follows: 0, no tear; 1, $<$50% tear; 2, $>$50% tear; or 3, 100% tear.

Results: A total of 284 (51%) of the 558 surgeries in this cohort revealed LT tears. According to the descriptive grading system, 22% were grade 1, 24% were grade 2, and 5% were grade 3. According to the Gray and Villar classification 3.7% had full rupture, 43% had a partial tear, and 4.5% had a degenerative tear. Patients with LT tears were significantly older and had worse preoperative functional scores; they did, however, have a greater range of motion. Intraoperatively, an association with larger labral tear size and acetabular chondral damage was found. Magnetic resonance arthrography was found to have low accuracy and sensitivity in detection of LT tears. No correlation to the pain level was found.

Conclusion: Ligamentum teres tears had a higher prevalence in this study than was published in the past, most probably attributable to a lower threshold used in defining a tear. The incidence is defined both using the Gray and Villar classification, as well as a new descriptive classification system that categorizes the LT according to amount of tearing.

Keywords: ligamentum teres tears; hip arthroscopy; hip pain

The ligamentum capitis femoris, more commonly referred to as the ligamentum teres (LT), has been found in clinical literature since the 19th century, in both pathologic as well as healthy hips.[21] However, it continues to be imprecisely understood vis-à-vis its functional role as opposed to being simply considered a vestigial structure.[6,11,14,16,23,25] Nonetheless, it is well known that LT tears can be a cause of hip pain.[1,4,5,8,10,22,26] The awareness of LT tears has increased with advancements in hip arthroscopy over recent years. Moreover, a substantial increase of interest in the LT followed Gray and Villar's publication in 1997 of their nosologic construct of 3 types of ruptures of the LT.[1,8] According to this classification system, grade 1 LT tears are full traumatic tears; grade 2, partial tears; and grade 3, degenerate tears.[8]

Following our hip arthroscopy findings of LT tears using the Gray and Villar classification, we have found that 83% of the cases with LT tears had partial tears. Only 9% had degenerative tears, of which one-third had a full-thickness atraumatic tear. Because most of our patients were found to have partial tears, we additionally created a categorization according to the degree of tearing (Table 1). The main

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TABLE 1
Ligamentum Teres (LT) Classification Systems: the Gray and Villar Classification and the New Descriptive Classification

LT Tear	Gray and Villar Classification	Descriptive Classification
Grade 1	Full-thickness tear	Low-grade tear (<50% torn)
Grade 2	Partial-thickness tear	High-grade tear (>50% torn)
Grade 3	Degenerate tear	Full-thickness tear (100% torn)

purpose of this study was to report the prevalence of LT tears and existing relationships to patients' demographics, preoperative physical examination, and intraoperative pathologic lesions. A secondary purpose was to present a new classification system according to intraoperative findings that supplements the existing Gray and Villar classification.

METHODS

Patient Inclusion and Data Collection

Between February 2008 and January 2011, 616 hip arthroscopies were performed at our institution by the senior author (B.G.D.). The inclusion criteria for this study were all patients who underwent hip arthroscopy with an intraoperative examination of the LT. The exclusion criteria were previous hip surgery other than diagnostic hip arthroscopy.

A total of 558 hips (502 patients) met the inclusion/exclusion criteria. Objective data such as gender, age, height, weight, and body mass index (BMI) were collected. This study was institutional review board–approved.

Physical Examination

A detailed physical examination was conducted on all hips, including passive range of motion (ROM) measurements of flexion, abduction, internal rotation, and external rotation. Internal and external rotations were measured while the patient was in a supine position with both the hip and knee flexed to 90°. The examination was performed and documented in degrees by the senior author in a clinical setting.

Imaging

Magnetic resonance images of the hip were obtained in 554 of the cases; 470 had a magnetic resonance arthrogram (MRA), and 84 had plain MRI. Four patients did not have MRI done because of the presence of metal parts in the body (eg, nerve stimulation device) or other medical reasons. Examinations were done at 73 different institutions by 78 radiologists; however, 59% (327 cases) were obtained at our institution by 6 primary radiologists. Images were evaluated for cartilage damage, LT ruptures, labral tears, and other soft tissue pathologic lesions.

Preoperative Hip Scores

All patients undergoing hip arthroscopy were prospectively assessed. This preoperative protocol included the administration of 4 hip-specific questionnaires: the modified Harris hip score (mHHS),[3] the nonarthritic hip score (NAHS),[5] the Hip Outcome Score–Activities of Daily Living (HOS-ADLs), and the Hip Outcome Score–Sport-Specific Subscale (HOS-SSS).[9] If a patient was not able to take the survey in a clinical setting, it was administered over the phone. A total of 32 surveys (5.7%) were given over the phone, while the rest were completed in the clinical setting. Sixty-two patients (12%) did not complete the survey preoperatively, or were incorrectly administered the survey.

In addition to preoperative hip scores, patients were also asked to estimate their pain on a visual analog scale (VAS) from 0 to 10, where 0 was considered to be no pain at all and 10 was considered to be the worst possible pain. The VAS scores for all patients were successfully determined preoperatively.

Patients were asked by the operating physician when and by what mechanism the pain began. The duration of symptoms was recorded. Pain was considered acute in onset if the patient noted a specific moment in time at which pain began. Traumatic onset of pain was also noted.

Intraoperative Findings

All arthroscopies were performed by the senior author with the patient in the modified supine position, using a minimum of 2 portals (anterolateral and midanterior).[13] The LT was observed routinely during all hip arthroscopies and visual assessment of presence of torn fibers was made (Figure 1). When needed, an arthroscopic probe was used for further examination of the ligament. Ligamentum teres tears were classified according to 2 systems. The first was the Gray and Villar classification[8]: 1, complete; 2, partial; and 3, degenerative tears. The second was a new descriptive classification, which divided the tears according to the tear percentage of the LT (Table 1). The new classification included grade 0, no tear; grade 1, low-grade partial LT tear <50% (Figure 2 and Video 1 [see video supplement, available in the online version of this article at http://ajs.sagepub.com/supplemental/]; grade 2, high-grade partial LT tear >50% (Figure 3); and grade 3, full-thickness LT tear (Figure 4 and Video 2 [available online]).

Other intraoperative data included the size of concomitant labral tears (measured in number of hours on the clock face) and the presence and location of acetabular cartilage lesions. The Acetabular Labrum Articular Disruption (ALAD) classification system[12] was used on the acetabular side and the Outerbridge classification[17] was used to classify femoral head cartilage damage (Table 2).

All LT tears involving >50% of the fibers were debrided using a radiofrequency device. Acetabular labral tears were refixated whenever possible using a simple loop stitch or a labral base refixation technique.[7] Irreparable labral tears were partially debrided or reconstructed using

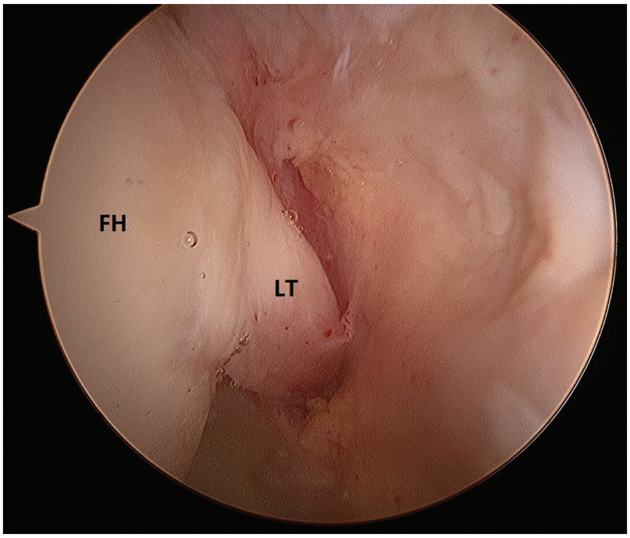


Figure 1. Arthroscopic appearance of a normal ligamentum teres (LT). FH, femoral head.

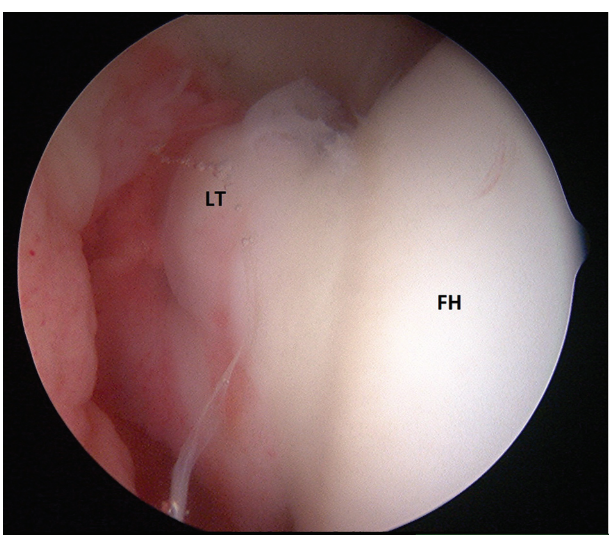


Figure 2. Descriptive grade 1: low-grade (<50%) partial tear of the ligamentum teres (LT). In this case, minor fraying of the ligamentum is seen arthroscopically. These may not be considered tears in other studies. (See also Video 1 [available online]. FH, femoral head.

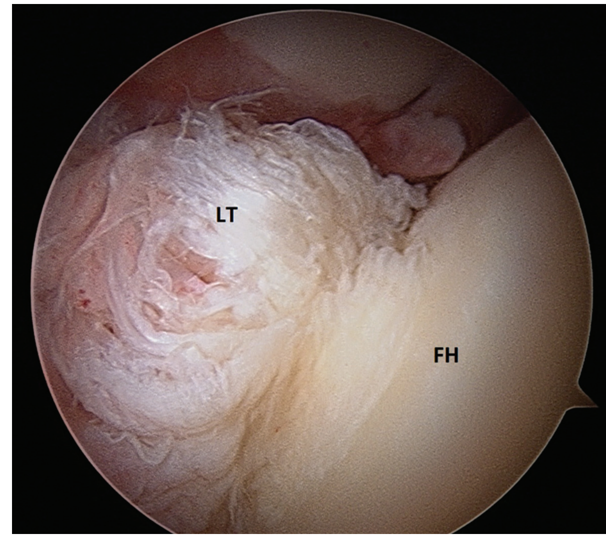


Figure 3. Descriptive grade 2: high-grade (>50%) partial tear of the ligamentum teres (LT). FH, femoral head.

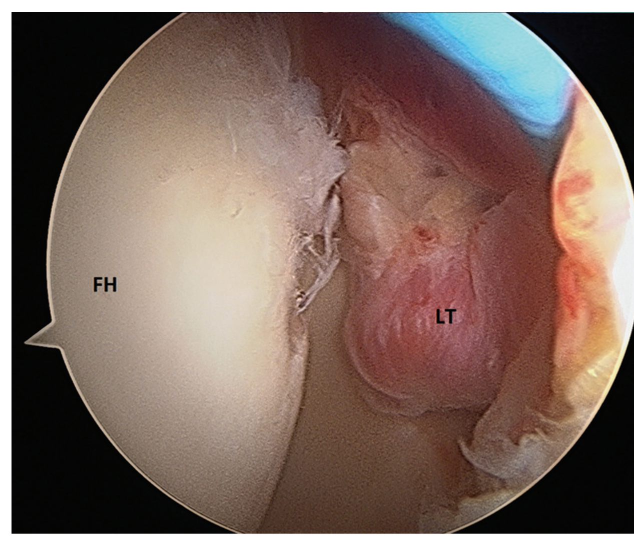


Figure 4. Descriptive grade 3: full-thickness tear of the ligamentum teres (LT). The ligamentum stump is seen clearly. (See also Video 2 [available online]). FH, femoral head.

a gracilis tendon autograft (Table 3). All other lesions were addressed as well (Table 4).

Statistical Analysis

Comparisons of 2 continuous variables were performed using the Pearson correlation coefficient test. Comparison of a continuous variable between categorical groups was performed with an unpaired 2-tailed Student *t* test (2 categorical variables) or 1-way analysis of variance (>2 categorical variables). Comparison of categorical values was performed using the χ^2 test. Statistical analysis was done using Microsoft Office Excel 2007 (Microsoft, Redmond, Washington). Alpha values of <.05 were considered statistically significant.

RESULTS

The patient population consisted of 232 male and 326 female patients with a mean population age of 39.3 years (range, 15-78 years). The average weight was 76.59 kg (range, 45.4-141.65 kg), the average height was 1.72 m (range, 1.49-1.98 m), and the average BMI was 25.76 (range, 15.23-52). Of the 558 cases, 51% (284 cases) were identified to have a tear of the LT (Table 5).

TABLE 2
Two Systems to Classify Cartilage Damage[a]

Damage Grade	ALAD Cartilage Damage	Outerbridge Cartilage Damage
Grade 1	Softening	Softening and swelling
Grade 2	Early peel of the cartilage (carpet delamination)	Partial-thickness defect that does not reach the surface of the bone
Grade 3	Large flap of cartilage	Fissuring to the level of subchondral bone with area <1.5 cm^2
Grade 4	Cartilage completely missing	Exposed subchondral bone

[a]The Acetabular Labrum Articular Disruption (ALAD) classification system[12] was used for the acetabular side, while the Outerbridge classification[17] was used for the femoral head.

TABLE 3
Treatment of Labral Tears[a]

	LT Tear (n = 281)	No LT Tear (n = 269)	*P* Value
Debridement	123 (43.77)	92 (34.20)	.072703
Labral base refixation	28 (9.96)	51 (18.96)	**.005398**
Simple stitch refixation	116 (41.28)	119 (44.24)	.59591
Combined refixation	9 (3.20)	3 (1.12)	.097547
Reconstruction	5 (1.78)	4 (1.49)	.788744

[a]Data are presented as n (%). LT, ligamentum teres. **Boldface type** indicates significance ($P < .05$).

TABLE 4
Arthroscopic Procedures Performed[a]

	LT Tear (n = 284)	No LT Tear (n = 274)	*P* Value
Acetabuloplasty	192 (67.61)	220 (80.29)	.081246
Osteoplasty	185 (65.14)	180 (65.69)	.935693
Microfracture	31 (10.92)	15 (5.47)	**.025229**
Iliopsoas release	40 (14.08)	68 (24.82)	**.003964**
Labral treatment	281 (98.94)	269 (98.18)	.927168

[a]Data are presented as n (%). LT, ligamentum teres. **Boldface type** indicates significance ($P < .05$).

Tear Incidence by Classifications

According to the Gray and Villar classification, 21 patients had a full rupture, 238 had a partial tear, and 25 had a degenerative tear (Table 6). By the descriptive classification, 122 patients had grade 1 tears, 134 had grade 2 tears, and 28 had grade 3 tears (Table 6).

Patients with LT tears were not statistically dissimilar from patients without LT tears according to their gender. Similarly, for the descriptive and Villar classification, there was no statistical difference between grades with respect to gender. However, the average age of patients with LT tears was much higher (42.3) than for patients with no tear (36.2) ($P < .0001$ for both). No relation was found between BMI and LT tearing.

Physical Examination Findings

The physical examination before the surgery resulted in the following mean ROM for the affected hip joint: flexion of 117.7° (range, 45° to 150°), abduction of 44.5° (range, 0° to 85°), internal rotation of 21.8° (range, −10° to 90°), and external rotation of 50.2° (range, 5° to 90°). Patients with LT tears had greater flexion and internal rotation ($P = .02$ and .06 respectively), while abduction and external rotation were not significantly different ($P = .16$ and .97, respectively) (Table 5A).

Magnetic Resonance Imaging Results

In total, 9 hips were diagnosed with LT tears based on preoperative imaging: 7 according to MRA and 2 according to plain MRI. Of these 9 cases, LT tears were identified in only 5 at the time of arthroscopy; the remaining 4 were considered false positives. All 5 tears that were correctly identified preoperatively were partial-thickness tears: 4 were low grade and 1 was high grade (Table 7). There were a total of 278 false-negative reports and 267 true-negative reports of LT tearing on MRA. The sensitivity for identification of LT tears with MRA for all patients was 1.8%, while the specificity was 98.5%. The positive predictive value was 56% and the negative predictive value was 49%.

Hip Scores

Patients with LT tears had lower average preoperative NAHS, HOS-SSS, and HOS-ADL scores than patients without LT tears ($P < .05$ for all 3 scores). For the mHHS score, however, patients with LT tears did not significantly differ from patients without LT tears. In multicategory comparison, there was a significant difference in HOS-ADL and NAHS scores between the descriptive grades, with lower scores with higher grades of tears ($P < .05$ for both). There was no significant difference between the mHHS and HOS-SSS scores of patients with differing descriptive grade tears. Similarly, NAHS scores were lower for patients with Gray and Villar type 3 tears (mean = 48.2; range, 12.5-86.3) than type 1 and 2 tears and patients without tears (means = 56.7, 54.2, and 58.6, respectively; $P < .05$) (Table 5).

Pain

Patients without LT tears were found to have a comparable VAS score as patients with tears ($P = .47$). The VAS was determined to have no relation to either the descriptive

TABLE 5
Patient Demographics, Including Comparison According to the Presence of Ligamentum Teres (LT) Tear and the 2 Classification Systems[a]

A. Comparison of patients with an LT tear versus patients without a tear

Data	All Patients (N = 558)	Positive Tear (n = 284)	No Tear (n = 274)	*P* Value: Positive vs No Tear
Age, y	39.3 (15.5 to 78.3)	40.87 (14 to 74)	36.20 (15.6 to 78.3)	<.0001
BMI	25.8 (15.2 to 52.0)	25.76 (16.24 to 47.92)	25.76 (17.2 to 51.1)	.99
Duration of symptoms, mo	25.1 (0.8 to 240)	23.53 (1 to 204)	26.8 (0.8 to 240)	.3
VAS	6.19 (0 to 10)	6.25 (0 to 10)	6.1 (0 to 10)	.47
Preoperative mHHS	60.15 (0 to 100)	59.00 (0 to 100)	61.3 (0 to 96.8)	.12
Preoperative HOS-ADLs	61.7 (0 to 100)	58.91 (0 to 98.52)	64.7 (0 to 100)	<.005
Preoperative HOS-SSS	39.98 (0 to 100)	37.43 (0 to 100)	42.7 (0 to 100)	.03
Preoperative NAHS	56.14 (0 to 98.75)	53.82 (0 to 96.25)	58.6 (0 to 98.75)	<.01
Preoperative abduction, deg	44.5 (0 to 85)	45.16 (0 to 85)	43.8 (5 to 80)	.16
Preoperative flexion, deg	117.7 (45 to 150)	119.27 (45 to 150)	11.6 (70 to 150)	.02
Preoperative internal rotation, deg	21.81 (–10 to 90)	23.00 (–10 to 70)	20.6 (–5 to 90)	.06
Preoperative external rotation, deg	50.24 (5 to 90)	50.21 (5 to 90)	50.3 (10 to 90)	.97
Labral tear, h	3.0 (0.5 to 10)	3.11 (0.5 to 10)	2.93 (0.5 to 6)	.12

B. Comparison according to the Gray and Villar classification

Data	No Tear	Full-thickness Tear (Grade 1) (n = 21)	Partial-thickness Tear (Grade 2) (n = 238)	Degenerate Tear (Grade 3) (n = 25)	*P* Value
Age, y	36.2 (15.6 to 78.3)	42.1 (18.7 to 67.0)	41.5 (15.5 to 75.1)	50.0 (30.4 to 75.0)	<.0001
BMI	25.8 (17.2 to 51.1)	26.6 (18.3 to 42.4)	25.5 (16.2 to 52.0)	27.7 (19.2 to 36.9)	.25
Duration of symptoms, mo	26.8 (0.8 to 240.0)	18.3 (1 to 48)	22.6 (1 to 204)	36.6 (3 to 204)	.17
VAS	6.1 (0 to 10)	6.5 (2 to 10)	6.2 (0 to 10)	6.5 (3 to 10)	.06
Preoperative mHHS	61.3 (0 to 96.8)	59.3 (33 to 100)	59.6 (16.5 to 95.7)	53.6 (0 to 90.2)	.16
Preoperative HOS-ADLs	64.7 (0 to 100)	62.8 (23.5 to 98.5)	59.4 (0 to 98.5)	51.3 (7.4 to 83.8)	.004
Preoperative HOS-SSS	42.7 (0 to 100)	43.5 (0 to 88.9)	37.5 (0 to 100)	32.0 (0 to 75)	.07
Preoperative NAHS	58.6 (0 to 98.8)	56.7 (22.5 to 96.3)	54.2 (0 to 92.5)	48.2 (12.5 to 86.3)	.02
Preoperative abduction, deg	43.8 (5 to 80)	47.9 (25 to 80)	45.42 (0 to 85)	40.4 (25 to 50)	.05
Preoperative flexion, deg	116 (70 to 150)	119.0 (90 to 135)	120.0 (45 to 150)	112.3 (50 to 135)	.02
Preoperative internal rotation, deg	20.6 (–5 to 90)	20.7 (0 to 60)	23.0 (–10 to 70)	24.8 (0 to 60)	.23
Preoperative external rotation, deg	50.3 (10 to 90)	53.1 (10 to 80)	50.0 (5 to 90)	49.6 (25 to 75)	.83
Labral tear, h	2.9 (0.5 to 6)	3.6 (0.5 to 10)	3.04 (1 to 7)	3.40 (0.5 to 6)	.09

C. Comparison according to the descriptive classification

Data	No Tear	Low-grade Tear (Grade 1) (n = 122)	High-grade Tear (Grade 2) (n = 134)	Full-thickness Tear (Grade 3) (n = 28)	*P* Value
Age, y	36.2 (15.6 to 78.3)	38.8 (15.5 to 69.2)	44.9 (15.7 to 75.1)	45.0 (18.7 to 67.0)	<.0001
BMI	25.8 (17.2 to 51.1)	24.5 (16.2 to 42.9)	26.7 (18.08 to 52.0)	27.0 (18.3 to 42.4)	.12
Duration of symptoms, mo	26.8 (0.8 to 240)	23.3 (1.0 to 168.0)	23.7 (1 to 120)	23.6 (1 to –204)	.78
VAS	6.1 (0 to 10)	6.4 (0 to 10)	6.1 (1 to 10)	6.4 (2 to 10)	.06
Preoperative mHHS	61.3 (0 to 96.8)	58.6 (16.5 to 95.7)	60.1 (19.8 to 95.7)	55.7 (0 to 100)	.26
Preoperative HOS-ADLs	64.7 (0 to 100)	59.9 (14.7 to 98.5)	57.9 (0 to 96.4)	59.1 (7.4 to 98.5)	.02
Preoperative HOS-SSS	42.7 (0 to 100)	38.1 (0 to 100)	36.6 (0 to 100)	38.5 (0 to 88.9)	.16
Preoperative NAHS	58.6 (0 to 98.8)	54.4 (6.3 to 92.5)	53.21 (0 to 88.8)	53.9 (12.5 to 96.2)	.05
Preoperative abduction, deg	43.8 (5 to 80)	46.81 (10 to 80)	43.3 (0 to 85)	46.8 (25 to 80)	.03
Preoperative flexion, deg	116.0 (70 to 150)	119.9 (50 to 150)	119.0 (45 to 140)	118.0 (50 to 135)	.13
Preoperative internal rotation, deg	20.6 (–5 to 90)	23.6 (–10 to 50)	22.7 (0 to 70)	21.8 (0 to 60)	.57
Preoperative external rotation, deg	50.3 (10 to 90)	51.21 (5 to 90)	50.0 (20 to 90)	51.1 (10 to 80)	.99
Labral tear, h	2.9 (0.5 to 6)	2.91 (0.5 to 7)	3.2 (0.5 to 10.0)	3.41 (1 to 7)	.05

[a]Data are presented as mean (range). BMI, body mass index; VAS, visual analog scale; mHHS, modified Harris hip score; HOS-ADLs, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sport-Specific Subscale; NAHS, nonarthritic hip score.

TABLE 6
Comparison of Prevalence of Ligamentum Teres Tears According to the Gray and Villar and the Descriptive Classifications

	Gray and Villar					
Descriptive	No Tear	Full Tear	Partial Tear	Degenerate Tear	Total	Percentage
No tear	274	0	0	0	274	49.1%
Low-grade tear	0	0	118	4	122	21.86%
High-grade tear	0	0	120	14	134	24.01%
Full-thickness tear	0	21	0	7	28	5.02%
Total	274	21	238	25	558	100%
Percentage	49.10%	3.76%	42.65%	4.48%	100%	

TABLE 7
Intraoperative Findings in Patients With Positive MRI Results for Ligamentum Teres Tears

MRI Patient With Positive Result	Intraoperative Descriptive Grade	Intraoperative Villar Grade
Patient 1	No tear	No tear
Patient 2	No tear	No tear
Patient 3	No tear	No tear
Patient 4	No tear	No tear
Patient 5	Low grade	Partial
Patient 6	Low grade	Partial
Patient 7	Low grade	Partial
Patient 8	Low grade	Partial
Patient 9	High grade	Partial

classification or Gray and Villar classification ($P > .05$). Thus, a higher-grade LT tear seems to have no relationship to a patient's perceived level of pain (Table 5).

Of 558 cases, 34.2% had an acute onset of pain. There was no significant difference between patients with and without LT tears with respect to acuity of onset of pain. For the 30 hips with full-thickness tears, 9 had a sudden onset of pain, while 21 did not. Of these 9 cases, 4 had acute onset attributable to a traumatic accident (3 were hit by a moving vehicle and 1 was crushed by a forklift). There was, however, no association found between an acuity of onset of pain and descriptive or Gray and Villar classes (P = .75 and .86, respectively).

Duration of Symptoms

The average duration of symptoms experienced prior to surgery for all patients was 25.1 months (range, 0.8-240 months). Patients without LT tears did not experience pain for a significantly different amount of time than patients with LT tears. There was no statistical difference in months of symptoms between descriptive or Gray and Villar grades (Table 5).

Intraoperative Findings

During hip arthroscopy, labral tears were identified in 95% of cases, with a mean labral tear size of 3.0 hours on the clock face (range, 0.5-10 hours). Patients with LT tears had a mean labral tear size of 3.11 hours, which was, on average, slightly larger than the mean labral tear size of 2.93 hours for patients without LT tears (P = .12). It was found that as the descriptive grade increases, labral tear size also significantly increases ($P < .05$), from an average of 2.93 hours for patients without tears to a mean of 3.41 hours for patients with full-thickness LT tears. There was not a significant difference between Gray and Villar groups with respect to size of labral tears (P = .09) (Table 5).

There was no significant difference between either the descriptive or Gray and Villar grades with respect to the femoral head Outerbridge classification (all P values $>.05$). There was also no difference between patients with and without LT tears with respect to femoral head cartilage damage ($P > .05$).

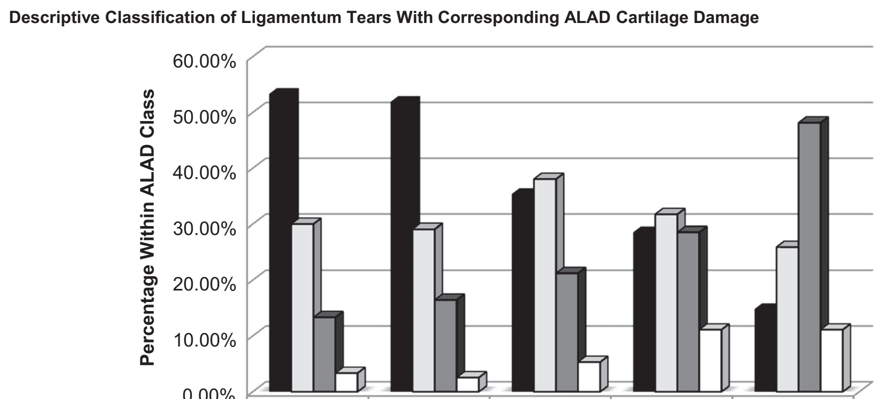
With respect to the Acetabular Labrum Articular Disruption classification of cartilage damage, patients with ligamentum tears were more likely to have higher-grade cartilage damage than patients without tears ($P < .005$). For the descriptive classification, there was a progressively higher percentage of patients with LT tears as the severity of the Acetabular Labrum Articular Disruption–classification lesions increased (Figure 5). Additionally, as the severity of the lesions increased, there was also an increase in the percentage of patients with descriptive grade 2 LT tears. Cartilage damage grade was also significantly different between Gray and Villar grades (P = .03).

Arthroscopic Procedures

The arthroscopic procedures performed are summarized in Table 4. Microfracture was done more for patients with LT tears (P = .03), while iliopsoas tendon release was done more for patients without LT tears (P = .004). There was no significant difference in rate of osteoplasty, acetabuloplasty, or treatment of labral tears between patients with and without LT tears.

Labral Tear Treatment Method

The methods of treatment of labral tears are summarized in Table 3. Labral base refixation was performed less commonly for patients with LT tears (10%) than those without LT tears (19%) (P = .005).



	ALAD 0	ALAD 1	ALAD 2	ALAD 3	ALAD 4
■ No Tear Descriptive (Grade 0)	53.33%	51.90%	35.40%	28.57%	14.81%
□ Low-grade Partial-thickness Tear (Descriptive Grade 1)	30.00%	29.11%	38.05%	31.75%	25.93%
■ High-grade Partial-thickness Tear (Descriptive Grade 2)	13.33%	16.46%	21.24%	28.57%	48.15%
□ Full-thickness Tear (Grade 3)	3.33%	2.53%	5.31%	11.11%	11.11%

Figure 5. Acetabular Labrum Articular Disruption (ALAD) cartilage damage and descriptive grades. A change is noted between the groups, with an increasing rate of the descriptive grade 2 ligamentum teres tears with higher ALAD grade cartilage lesions.

DISCUSSION

Although the function of the LT has been considered extensively, its role is still debatable. In the 19th century, it was known that the LT had great strength. It was also believed that the LT was perhaps related to stability of the hip joint and that its tightness was dependent on the femoral position, mainly flexion and adduction. Furthermore, it was theorized in 1874 that the LT was necessary to distribute force throughout the acetabulum while weightbearing.[21] Today, there is no doubt that this ligament is as strong as the anterior cruciate ligament, and tight in flexion, adduction, and external rotation.[1,24] Some hip preservation surgeries, such as open surgical dislocation, require routine resection of the LT. This approach presumes that the LT does not have a major role in hip stability. In contrast, others think it is critical in hip stability, and suggest its reconstruction in cases of suspected micro-instability.[22]

Two histologic studies have found type IVa free nerve endings in the LT, which are nociceptors and mechanoreceptors.[15,20] Leunig et al[15] suggested that in addition to its mechanical and structural functions, the LT may be involved in transmitting specific somatosensory afferent signals to the spinal and cerebral regulatory systems. Hence, the LT may be part of an integral reflex system involved in joint protection, acting as a rein avoiding excessive motion that may be potentially harmful to the joint.

Gray and Villar[1,8] suggest that there may be a so-called "windshield wiper" role that the LT provides by aiding in the proper distribution of synovial fluid in the hip joint. The experimental evidence for this, however, is lacking. Bardakos and Villar[1] subsequently reviewed additional mechanical (stability and proprioception) and biologic (nociception and vascularity to the femoral head) roles of the LT, noting evidence both for and against such theorized functions.

The reported prevalence of LT tears found during hip arthroscopy in the literature is between 4% and 17.5%.[1,2,10,19] Our study found a 51% prevalence of LT tears in a cohort of 558 hip arthroscopies. This difference can be explained by the inclusion of low-grade partial-thickness tears (22%), and by the increased awareness of LT tears over the past few years. Low-grade LT tears may range from fraying to tearing of <50% of the ligament (Figure 2 and Video 1 [available online]). We suspect that previous studies may not have considered these to be tears, and indeed, their clinical significance is unknown.

In the published literature, the physical examination of patients with LT tears describes a reduced and painful ROM in internal rotation and extension.[1,4,5,14] However, Byrd and Jones[4] reported reduced rotation under anesthesia in 6 of 23 patients, while in 3 patients the ROM was not limited. In contrast, our study showed increased ROM for patients with LT tears (Table 5A). We cannot conclude from our results that LT tearing is directly related to the ROM in the hip, and the clinical significance of this relationship has yet to be established. For example, this difference may be attributable to bony morphologic differences in patients with LT tears that affect the ROM in the hip. Because this study contains a heterogeneous cohort, we did not evaluate the bony morphologic characteristics of these patients. However, in a different study that was conducted on a younger population without arthrosis and traumatic injuries, a lower rate of acetabular retroversion was found in patients with LT tears.

Magnetic resonance arthrography is considered to be the gold standard for preoperative detection of LT tears.[2,5]

However, this study presents very low sensitivity rates of magnetic resonance. Only 9 hips were diagnosed with LT tears, of which only 5 were confirmed arthroscopically (Table 7). In other words, the sensitivity to detect LT tears by magnetic resonance in our cohort was less than 2% and the positive and negative predictive values were only 56% and 49%, respectively. In a study by Rao et al,[19] only 4% of patients with Villar grade 1 tears and 4% of patients with Villar grade 2 and 3 tears were identified preoperatively via MRI. They suggest that modern imaging techniques rarely identify the presence of a LT tear preoperatively. In another study, of 20 conducted MRI scans, 7 MRAs, and 7 CT scans, only 2 LT tears were correctly diagnosed preoperatively via MRA.[4] The results herein agree with findings from previous studies, and highlight the need for the development of improved diagnostic imaging of LT tears.

Many ligament injuries in other parts of the body result from acute trauma. However, in this study, most of the patients did not report an acute onset of the pain. Acute onset was noted in only 34% of the patients, with no significant difference in acuity between the patients with or without LT tear. Of the 28 hips with full-thickness tears according to the descriptive classification, only 9 had an acute onset of pain and only 4 had acute onset attributable to a traumatic accident. These findings suggest that in our group of patients, most LT tears resulted from a subtle injury, repetitive stress, or micro-instability.

Despite the many conflicting theories as to functionality, there is a significant and growing scientific literature and clinical experience to indicate that damage to the LT results in both hip pain and functional symptoms.[1,4,10] The significance of the LT as a cause of symptoms is supported by studies demonstrating free type IVa nerve endings within the ligamentum.[15,20] Haviv and O'Donnell[10] showed good results in 29 patients after debridement of isolated LT tears, demonstrating improvement on the mHHS and NAHS 1 year postoperatively. However, 5 patients needed revision arthroscopy, and underwent redebridement of the LT and capsular plication subsequently leading to a positive result. In the current study, there were significant differences in the results of 3 hip-specific scores—NAHS, HOS-SSS, and HOS-ADLs—with lower scores in the group of patients with LT tears (Table 5). As there were no patients with isolated LT tears in this study, it may be that LT tears have an additional effect on hip pain and patients' disability. These results, however, cannot confirm a causal relationship between LT tearing and decreased preoperative hip scores because of confounding variables such as chondral damage, bony morphologic characteristics, and capsular instability.

A high rate of association between a torn LT, labral tears, and cartilage lesions has been shown in previous studies.[9,18] In this cohort, the presence of LT tears was correlated to labral tear size and acetabular chondral damage (as reflected by the Acetabular Labrum Articular Disruption classification). Patients with LT tears also had larger labral tear size. Regarding chondral damage, hips with grade 4 lesions were 3.6 times more likely to have a high-grade partial-thickness LT tear than patients without chondral lesions (Figure 5). This relationship may explain the higher rate of microfracture performed on the group of patients with LT tears. However, causality cannot be established in the presence of multiple confounding variables. For the Gray and Villar classification, there was a significant difference in the cartilage damage grade between classes, but no distinct pattern between increasing grade and ligamentum tear type. This is logical, as the Gray and Villar classification is based on a nominal scale rather than an ordinal scale.

The publication of Gray and Villar's classification for LT tears was a milestone in the description of LT pathologic abnormalities. As an adjunct, the descriptive classification system suggested herein offers differentiation of partial tears with taxonomic order. In such a nomenclature, a higher score indicates more severe rupture. Finally, this taxonomy does not require identification of the cause of the tear; as such, it describes the pathologic lesion only.

The most significant strength of this study is that it reports the prevalence of LT tears in a large cohort of hip arthroscopies. This appears to be unique in the current literature as, to our knowledge, there are no other studies of the same scale that report LT prevalence, association with physical examination, imaging findings, and intraoperative findings. Moreover, by using a descriptive classification to define the incidence of various degrees of LT tearing, this study includes low-grade partial-thickness tears that may have been disregarded in previous literature. Finally, this study notes the lack of accuracy and sensitivity of MRA for the diagnosis of LT tears, highlighting the need for improved imaging.

This study aims to provide a visual assessment and classification of LT tears in which partial tears above and below 50% can be identified. We cannot currently claim clinical significance related to the descriptive classification presented herein. In future studies, this patient population should be examined for postoperative results and clinical significance related to LT tearing.

The principal shortcoming of this study is that LT tears were classified by 1 surgeon at the time of surgery. As the grading of the LT tears by both classification systems depends upon direct arthroscopic evaluation during surgery, intra- and interobserver reproducibility of this taxonomy system could not be tested. Another limitation is that the LT lesions were not isolated; in 95% of the cases, a concomitant labral tear was present. Because of the referral nature of our clinic, the MRA studies were conducted in various institutions and reported by numerous radiologists. Nonetheless, similarly low sensitivity of MRA was found when outside MRA studies were excluded. This study is limited to a cross-sectional report of the prevalence of LT tears at the time of hip arthroscopy, and the clinical significance of the findings of this study has yet to be established. Finally, the descriptive classification used in this study is for purposes of observational reporting; it is not proposed as a validated or clinically relevant classification system.

CONCLUSION

This large cohort observational study reports an overall 51% prevalence of LT tears. The reported prevalence is higher than previous studies, likely because of increased awareness and the inclusion of low-grade partial-thickness tears. Ligamentum teres tears were found to be more prevalent in older patients; those hips with LT tears had greater ROM in flexion and internal rotation. Preoperative NAHS, HOS-SSS, and HOS-ADL scores were lower in patients with LT tears. The LT tears were also found to be correlated to larger labral tears and to higher-grade acetabular chondral damage. Magnetic resonance imaging and MRA had very low sensitivity in detecting LT tears. Alongside the Gray and Villar classification, the new descriptive classification system used in this study may offer an ordinal taxonomic approach by employing hierarchical categories.

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