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CLINICAL RESEARCH

What is the Best Clinical Test for Assessment of the Teres Minor in Massive Rotator Cuff Tears?

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Abstract

Background Few studies define the clinical signs to evaluate the integrity of teres minor in patients with massive rotator cuff tears. CT and MRI, with or without an arthrogram, can be limited by image quality, soft tissue density, motion artifact, and interobserver reliability. Additionally, the ill-defined junction between the infraspinatus and teres minor and the larger muscle-to-tendon ratio of the teres minor can contribute to error. Therefore, we wished to determine the validity of clinical testing for teres minor tears.

Question/Purposes The aim of this study was to determine the accuracy of commonly used clinical signs (external rotation lag sign, drop sign, and the Patte test) for diagnosing the teres minor's integrity.

Methods We performed a prospective evaluation of patients referred to our shoulder clinic for massive rotator cuff tears determined by CT arthrograms. The posterosuperior rotator cuff was examined clinically and correlated with CT arthrograms. We assessed interobserver reliability for CT assessment and used three different clinical tests of teres minor function (the external rotation lag sign, drop

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Each author certifies that his or her institution approved this investigation and that all investigations were conducted in conformity with ethical principles of research.

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sign, and the Patte test). One hundred patients with a mean age of 68 years were available for the analysis.

Results The most accurate test for teres minor dysfunction was an external rotation lag sign greater than 40°, which had a sensitivity of 100% (95% CI, 80%–100%) and a specificity of 92% (95% CI, 84%–96%). External rotation lag signs greater than 10° had a sensitivity of 100% (95% CI, 80%–100%) and a specificity of 51% (95% CI, 40%–61%). The Patte sign had a sensitivity of 93% (95% CI, 70%–99%) and a specificity of 72% (95% CI, 61%–80%). The drop sign had a sensitivity of 87% (95% CI, 62%–96%) and a specificity of 88% (95% CI, 80%–93%). An external rotation lag sign greater than 40° was more specific than an external rotation lag sign greater than 10° ($p < 0.001$), and a Patte sign ($p < 0.001$), but was not more specific than the drop sign ($p < 0.47$). There was poor correlation between involvement of the teres minor and loss of active external rotation.

Conclusions Clinical signs can predict anatomic patterns of teres minor dysfunction with good accuracy in patients with massive rotator cuff tears. This study showed that the most accurate test for teres minor dysfunction is an external rotation lag sign and that most patients' posterior rotator cuff tears do not lose active external rotation. Because imaging is not always accurate, examination for integrity of the teres minor is important because it may be one of the most important variables affecting the outcome of reverse shoulder arthroplasty for massive rotator cuff tears, and the functional effects of tears in this muscle on day to day activities can be significant. Additionally, teres minor integrity affects the outcomes of tendon transfers, therefore knowledge of its condition is important in planning repairs.

Level of Evidence Level III, diagnostic study.

Introduction

The teres minor seems to be a forgotten muscle in the evaluation and management of rotator cuff disorders [25]. However, evidence suggests that its integrity may be one of the most important variables affecting the outcome of reverse shoulder arthroplasty for massive rotator cuff tears [10, 22]. The functional effects on day-to-day activities can be important [4, 18, 20], and previous research [5] has shown that teres minor integrity affects the outcomes of tendon transfers in massive rotator cuff tears.

Given these correlations, it is important to accurately assess teres minor integrity. Several clinical tests have been proposed to evaluate the combined integrity of the teres minor and the infraspinatus [3, 13, 19, 21, 24]. However, there is considerable overlap and confusion regarding their usage, validity, and interpretation [3, 13, 19, 21, 24]. Additionally, no studies, to our knowledge, have defined the clinical signs to isolate the integrity of teres minor in patients with a massive rotator cuff tear.

The primary aim of our study was to determine the accuracy of commonly used clinical signs (external rotation lag sign, drop sign, and the Patte test) for diagnosing the integrity of the teres minor. The second study aim was to assess the effect of teres minor insufficiency on shoulder function.

Materials and Methods

Patient Selection

Between March 2008 and April 2011, patients with a rotator cuff tear evaluated in a shoulder clinic were considered potentially eligible for this prospective study. The inclusion criterion was a massive rotator cuff tear, defined as a complete tear of two or more tendons [9], observed on a CT arthrogram. We ordered a CT arthrogram for all patients without prior imaging who were suspected of having a rotator cuff tear during the study period. If a patient initially was referred with MR images and a massive rotator cuff tear was observed, a CT arthrogram also was performed. Rotator cuff dysfunction was defined as muscular fatty infiltration greater than grade 3 according to the criteria of Goutallier et al. [11]. To ensure the tendon was nonfunctional, fatty infiltration greater than Grade 3 was used as the criterion for the diagnosis, as it is

Table 1. Baseline characteristics

Type of rotator cuff tears	Number of patients	Mean age (plus SD) (years)	Male	Dominant/ nondominant (number)	Right/left (number)
A	8	63.9 ± 5.4	6 (75%)	6/2	5/3
B	20	69.5 ± 9.2	8 (40%)	15/5	14/6
C	22	70.0 ± 8.0	11 (50%)	18/4	19/3
D	35	66.4 ± 7.8	18 (51%)	19/16	20/15
E	15	68.2 ± 7.6	7 (47%)	12/3	11/4

A = supraspinatus and superior subscapularis; B = supraspinatus and full subscapularis; C = infraspinatus, supraspinatus, superior subscapularis; D = supraspinatus and infraspinatus; E = supraspinatus, infraspinatus, teres minor.

indicative of complete fatty infiltration of the muscle compartments and shows chronic impairment and a poor-functioning musculotendinous unit. Exclusion criteria were incomplete documentation, limited passive shoulder ROM, a previous shoulder operation, substantial glenohumeral osteoarthritis (classification of Hamada et al. [12] greater than Grade 3), and inadequate CT arthrograms that prevented analysis of fatty infiltration. Institutional review board approval was obtained before the study began.

This study included 112 patients; 12 patients were excluded from the study owing to incomplete documentation, and no patients declined to participate. This resulted in 100 patients (50 men and 50 women) with a mean age of 68 ± 8 years (range, 50–84 years) who were available for the analysis (Table 1).

Study Variables and Clinical Evaluation

The methods were described in an earlier study [4] and consisted of standard baseline characteristics and recording of ROM in all patients. Pseudoparalysis was defined as less than 90° active anterior elevation with maintained passive elevation [26]. Boileau et al. [2] described a combined loss of active elevation and external rotation leaving patients unable to control spatial positioning of their upper limb. We considered this phenomenon to correspond to pseudoparalysis and external rotation strength less than 3 (inability to overcome gravity).

Muscular strength of the rotator cuff was graded 0 to 5, according to the Medical Research Council [17]. Tests used to assess the posterosuperior rotator cuff included the external rotation lag sign [13] (Fig. 1), the drop sign [13] (Fig. 2), and the Patte test [21] (Fig. 3) [21]. The external rotation lag sign was designed to test the integrity of the infraspinatus and supraspinatus tendons. The extent of internal rotation was recorded to the nearest 10° (10°, 20°, 30° and 40° or greater). The drop sign was designed to assess function of the infraspinatus [13]. The Patte test is the only test that allowed us to analyze the muscular strength of the teres minor in case of deficient infraspinatus.

Discrepancies regarding clinical test analysis by the two surgeons (PC and GW) were rectified by mutual review and agreement in seven cases.

Radiographic Evaluation and Study Definitions

A standard set of radiographs consisting of true AP, lateral scapular, and axillary views were obtained for each patient. Glenohumeral arthritis was classified according to the criteria of Hamada et al. [12]. As teres minor rupture is difficult to determine, CT arthrograms were analyzed for

Fig. 1A–B (**A**) The external rotation lag sign is performed with the patient seated with the elbow flexed to 90° and the shoulder elevated 20° in the scapular plane. The arm is passively taken to maximal external rotation minus 5° to allow for elastic recoil. (**B**) The patient was asked to maintain that position as the clinician released the wrist. A positive test is defined as any internal rotation greater than 10°.

Fig. 2A–B (**A**) The drop sign is a lag sign beginning from 90° abduction in the scapular plane, with elbow flexion of 90°, and external rotation of the shoulder to 90°. From this position, the patient is asked to maintain the position against gravity (Medical Research Council Grade 3). (**B**) Failure to resist gravity and internal rotation of the arm is considered a positive drop sign.

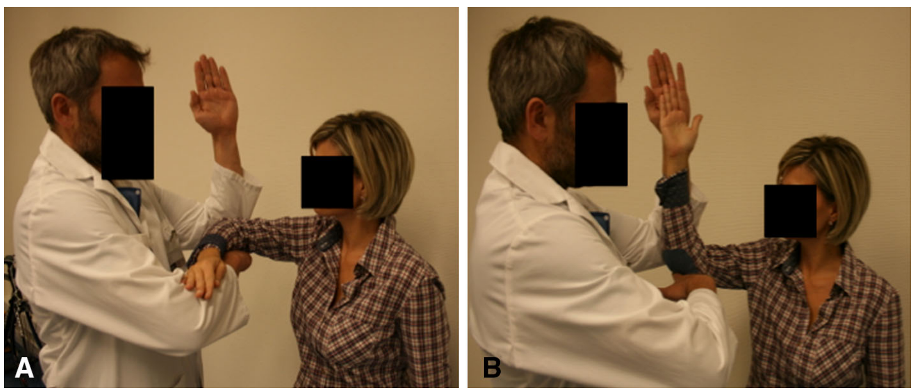

Fig. 3A–B (**A**) The Patte test is performed by passively taking the arm from a starting point of 90° abduction in the scapular plane and an elbow flexion of 90° without external rotation. (**B**) The patient is asked to perform external rotation of the shoulder from this position against resistance. A positive Patte test is defined as external rotation power less than Medical Research Council Grade 4.

fatty infiltration of the rotator cuff greater than Grade 3 as viewed in the sagittal plane (Fig. 4) [11, 18, 27]. Peripheral fatty tissue surrounding the muscles was viewed as extramuscular and was not taken into account. A training session to review and discuss the scoring system of Goutallier et al. [11] was completed by the two surgeons before they independently evaluated the images. Each surgeon independently reviewed each set of images once, resulting in two separate readings for each patient. Discrepancies were rectified by mutual review and agreement. The average κ value for interobserver agreement of fatty infiltration evaluation by the Goutallier system was 0.92, representing good agreement. No significant difference in subjective pain was observed between the five patient groups.

Based on CT arthrogram findings, the rotator cuff tears were divided in five components and then classified in five types (Fig. 5) [4].

Statistical Analysis

The sensitivity, specificity, accuracy, positive predictive value, and negative predictive value were calculated for each clinical test. Corresponding confidence intervals and p values between external rotation lag sign greater than 40° and other diagnostic tests were calculated for sensitivity and specificity with R v3.1.2 Portable (Free Software Foundation Inc, Vienna, Austria), as described by Trajman and Luiz [23]. We built 2 × 2 tables for each diagnosis of interest (Table 2) to calculate the effectiveness of different diagnostic tests. The interobserver reliability of the Goutallier scores were determined for each set of images by calculating a multijudge κ coefficient of agreement [6]. The sizes in degrees of the external rotation lag sign for the different groups were assessed and examined independently. Next, the means were compared, initially with a one way ANOVA of multiple means and then with Student's

Fig. 4 A sagittal view of a left shoulder CT arthrogram shows Grade 4 fatty infiltration of the infraspinatus and teres minor.

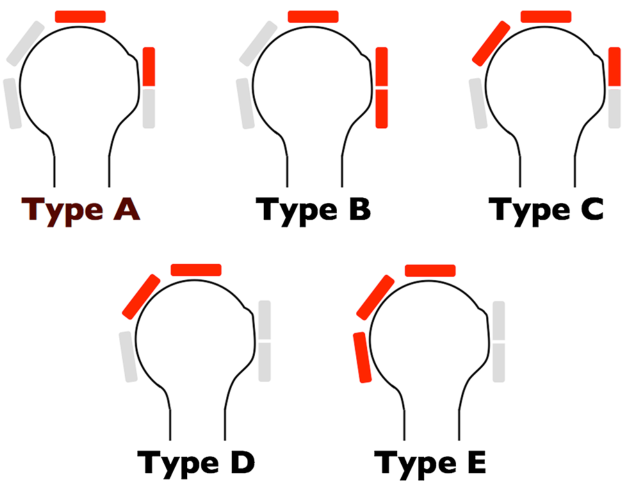

Fig. 5 The rotator cuff tears were divided into five components: the supraspinatus, superior subscapularis, inferior subscapularis, infraspinatus, and teres minor. Rotator cuff tear patterns were classified in five types: Type A, supraspinatus and superior subscapularis tears; Type B, supraspinatus and entire subscapularis tears; Type C, supraspinatus, superior subscapularis, and infraspinatus tears; Type D, supraspinatus and infraspinatus tears; and Type E, supraspinatus, infraspinatus, and teres minor tears. Therefore, patients with Type E tears were the only individuals with teres minor involvement. (Reprinted with permission from Elsevier from Collin P, Matsumura N, Lädermann A, Denard PJ, Walch G. Relationship between massive chronic rotator cuff tear pattern and loss of active shoulder range of motion. *J Shoulder Elbow Surg*. 2014;23:1195–1202.)

two tailed t-test between the individual groups with a probability value less than 0.05.

Results

Sensitivity and specificity analyses showed that the most accurate physical examination for determining the integrity

Table 2. 2 × 2 table for diagnosis of interest

Test	Teres minor deficient	Teres minor intact
External rotation lag sign		
≥ 10°	15	42
< 10°	0	43
≥ 40°	15	7
< 40°	0	78
Patte sign		
Present	14	24
Absent	1	61
Drop sign		
Present	13	10
Absent	2	75

of the teres minor was the external rotation lag sign greater than 40° (Table 3). A statistically significant difference was observed between specificity of the external rotation lag sign greater than 40° and external rotation lag sign greater than 10° ($p < 0.001$), and between the external rotation lag sign greater than 40° and the Patte sign ($p < 0.001$), whereas the specificity of the external rotation lag sign greater than 40° and drop sign was not statistically significant ($p = 0.45$). Differences observed in terms of sensitivity between external rotation lag sign greater than 40° and the other tests were not statistically significant ($p = 1$ for external rotation lag sign greater than 10°; $p = 1$ for Patte sign; $p = 0.47$ for drop sign). A positive external rotation lag sign was found in 0% of Type A, 15% of Type B, 72% of Type C, 65% of Type D, and 100% of Type E tears. The mean lag in groups A, B, C, D, and E were 0°, 2°, 20°, 18° and 66°, respectively. When comparing the groups individually, there was no difference between groups B, C, and D. There was a difference between E and all the other groups ($p < 0.0001$). There was also a difference between A and all the other groups (A versus C; $p = 0.021$; A versus D, $p = 0.023$).

The prevalence of combined loss of active elevation and external rotation was 0% (0 of eight) for Type A, 0% (0 of 20) for Type B, 22% (five of 22) for Type C, 4% (one of 35) for Type D, and 33% (five of 15) for Type E tears. Among patients with a tear of the teres minor, 33% had combined loss of active elevation and external rotation whereas in patients with an intact teres minor, 7% had combined loss of active elevation and external rotation.

Discussion

Our findings support the hypothesis that the most reliable test for teres minor assessment is the external rotation lag sign greater than 40°. The current study adds to the clinical

Table 3. Clinical performance in percentage of tests in the assessment of teres minor function

Test	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	Positive predictive value (%) (95% CI)	Negative predictive value (%) (95% CI
External rotation lag sign > 10°	100 (80–100)	51 (40–61)	26 (17–39)	100 (92–100)
External rotation lag sign > 40°	100 (80–100)	92 (84–96)	68 (47–84)	100 (95–100)
Patte sign	93 (70–99)	72 (61–80)	37 (23–53)	98 (91–100)
Drop sign	87 (62–96)	88 (80–93)	57 (37–74)	97 (9–99)

assessment of the teres minor which remains crucial even with modern imaging. CT and MRI, with or without an arthrogram, can be limited by image quality, soft tissue density, motion artifact, and interobserver reliability. In addition, the ill-defined junction between the infraspinatus and teres minor and larger muscle-to-tendon ratio of the teres minor can contribute to error.

There were limitations to our study. Our findings are limited to patients with a massive rotator cuff tear without glenohumeral arthritis. However, teres minor insufficiency mostly is seen with massive rotator cuff tears as an isolated lesion of the teres minor (only seen in case of quadrilateral space syndrome, congenital absence, or muscle agenesis) [15, 18]. We used CT arthrograms as the comparison to the clinical studies, but there are inaccuracies in the assessment of teres minor tears by CT, and we did not compare the findings with actual tears documented during surgery in these patients. We chose CT rather than MRI because (1) during the period of this study, it was a more-accessible examination method in our country, (2) fatty infiltration has been reliably determined through this method of imaging [18], and (3) Goutallier et al. [11] classified muscle quality by the amount of fatty infiltration in the rotator cuff muscle as identified on CT in the axial plane, with a thorough analysis of the whole muscle belly. With the advent of MRI, however, the classification was extrapolated to the most lateral parasagittal image on which the scapular spine was in contact with the scapular body (Y view) [7]. The latter is related to musclotendinous retraction frequently seen in massive rotator cuff tears. As a result, a normal muscle can be interpreted as completely fatty infiltrated if such MRI criteria are used, and there is no proof that MR images compared with CT scans allowed a better analysis of posterosuperior retracted muscles of the rotator cuff [18]. Moreover, discrepancies regarding analysis of clinical tests by the two surgeons (PC and GW) needed to be discussed in seven cases to attain mutual agreement. Finally, we did not quantify the role of teres minor hypertrophy in Types C and D massive rotator cuff tears as no publication, to our knowledge, at that time quantified these changes [14].

We found that the clinical tests all had varying degrees of accuracy in assessing teres minor tears. The most accurate and specific seems to be the external rotation lag sign greater than 40°. Teres minor testing was addressed specifically with the Patte test [24], comparing this test with teres minor changes seen on CT arthrograms. Thirteen patients in the study by Walch et al. [24] had a teres minor tear. They reported 100% sensitivity and 93% specificity with the Patte test and teres minor fatty atrophy Grade 3 or greater [24]. The dropping sign, as described by Neer [19], (the test is distinct from the drop sign in the current study) had 100% sensitivity and 66% specificity for teres minor involvement. Strength of the teres minor in external rotation with the elbow at the side represents approximately 20% of total external rotation strength [8].

However, its function may become more important with the presence of a chronic infraspinatus tear, as hypertrophy of the teres minor is commonly observed in these cases and probably compensates for external rotation weakness. Four previous studies have evaluated signs for posterosuperior cuff integrity [3, 13, 21, 24]. However, the populations in which they were performed were not limited to patients with massive rotator cuff tears and they focused mainly on the integrity of supraspinatus and infraspinatus. Castoldi et al. [3] examined accuracy of the external rotation lag sign in 395 shoulders, noting that there was a trend toward larger lags with extension of the tears in the teres minor tendon. However, they had only eight patients who had teres minor involvement. The Patte test and the drop sign, however, have acceptable accuracy and likelihood ratios for common use in the diagnosis of teres minor tears, with the drop sign being slightly better. The results that we achieved are not equivalent to those of Walch et al. [24], most likely owing to the difference in sample characteristics. They excluded subscapularis tears whereas we evaluated all massive rotator cuff tears.

We found a less-than-anticipated correlation between involvement of the teres minor and loss of active external rotation. Boileau et al. [2] described three clinical presentations in poorly compensated massive rotator cuff tears: isolated loss of external rotation, isolated pseudoparalysis, and combined loss of active elevation and external rotation. They suggested the latter situation was caused by combined teres minor, infraspinatus and supraspinatus failure [2]—an anatomy equivalent to the classification by Collin et al. [4]

of massive rotator cuff tear Type E, representing a vertical and horizontal muscular imbalance. However, in the current study, only 33% of patients with Type E tears showed a combined loss of active elevation and external rotation pattern. In addition, six patients with an intact teres minor had combined loss of active elevation and an external rotation pattern. This finding might be explained by a compensatory mechanism. Patients with Type E tears without combined loss of active elevation and external rotation presumably have improved posterior deltoid recruitment. Additionally, there is biomechanical data that posterior deltoid fibers can impart an external rotation moment on the shoulder in an experimental model [1, 16]. Boileau et al. [2] and Costouros et al. [5] reported on the importance of the teres minor on the outcome after latissimus dorsi transfer or reverse shoulder arthroplasty. Costouros et al. [5] reported that functional outcome decreased with an isolated latissimus tendon transfer when teres minor fatty degeneration was greater than Grade 2. Boileau et al. [2] reported on reverse shoulder arthroplasty combined with latissimus tendon transfers for patients with combined loss of active elevation and external rotation. They suggested that patients who are not able to maintain a minimum of neutral rotation with the arm at the side require latissimus tendon transfer in addition to reverse shoulder arthroplasty. However, in our study, only 33% of the patients with a Type E tear had a combined loss of active elevation and external rotation pattern, meaning that 66% of patients with teres minor tears maintain active external rotation. Therefore, a teres minor tear alone is likely an inadequate criterion for a latissimus dorsi transfer. Moreover, we found that several patients with an intact teres minor clinically showed combined loss of active elevation and external rotation. It is probable that these patients had either poor deltoid compensation or pain inhibition. As both of these factors would be addressed by a reverse shoulder arthroplasty alone, lack of active external rotation with the arm at the side may not be an adequate criterion for adding a latissimus transfer to a reverse shoulder arthroplasty.

Because of this study, we now begin posterior rotator cuff evaluation with the external rotation lag sign (Fig. 1). A positive external rotation lag sign generally allows us to detect a weakness of the infraspinatus, while an external rotation lag sign greater than 40° detects an insufficiency of the infraspinatus and teres minor. In patients with a negative external rotation lag sign but who present with weakness (Medical Research Council grade lower than 5) in external rotation with the shoulder elevated 20° in the scapular plane, we then perform the drop sign (Fig. 2) and the Patte maneuver (Fig. 3) to test more specifically the teres minor in 90° abduction.

The current study is the largest assessment to date of teres minor function in patients with massive rotator cuff tears. All patients were included prospectively and had a clinical examination correlated with imaging. Clinical signs can predict anatomic patterns of tendon failure with good accuracy in patients with a massive rotator cuff tear. For teres minor assessment, the most accurate sign of dysfunction was an external rotation lag sign greater than 40°, but the superiority over the drop sign was not formally established. This lack of statistical significance could be explained by the limited sample size of patients with a Type E rotator cuff tear. The Patte test offers less but still-acceptable accuracy. We found a less-than-anticipated correlation between involvement of the teres minor and loss of active external rotation. These findings may have clinical relevance when planning reverse total shoulder replacements or tendon transfers for massive rotator cuff repairs as the teres minor has been shown to be important for successful outcomes of these procedures [10, 22]. Furthermore, lack of teres minor function is a substantial functional disability, therefore the ability of the clinician to document this loss of function is important for advising patients on treatment options.

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