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ORIGINAL ARTICLE

Performance and return to sport in elite baseball players and recreational athletes following repair of the latissimus dorsi and teres major

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Background: Tears of the latissimus dorsi (LD) and teres major (TM) are rare but disabling injuries in the overhead athlete.
Methods: All patients who underwent an LD and/or TM repair between January 1, 2010, and June 6, 2016, with more than 12 months' follow-up were included. Demographic information and postoperative range of motion were recorded. Patients were contacted via phone and answered questions to provide the following: Kerlan-Jobe Orthopaedic Clinic (KJOC) shoulder and elbow outcome score, American Shoulder and Elbow Surgeons (ASES) shoulder score, and visual analog scale (VAS) score. Performance data for professional athletes were recorded preoperatively and postoperatively and compared by paired *t* tests.
Results: Eleven male patients aged 29.9 ± 12.4 years were included; 86% were right hand dominant, 86% underwent surgery on the dominant side, and 73% were pitchers (7 professional and 1 collegiate). The mean time from injury to repair was 389 ± 789 days; 36% of repairs were performed within 6 weeks of injury. At final follow-up, the VAS score was 0.7 ± 1.9, the ASES score was 100 ± 0, and the KJOC score was 93 ± 5. Professional (major and minor league) pitchers had a mean total time participating in professional baseball of 6.6 ± 3.9 years, with 3.9 ± 2.3 years before surgery and 2.7 ± 1.8 years after surgery. Among professional pitchers, the VAS pain score was 0.0 ± 0.0, the ASES score was 100 ± 0, and the KJOC score was 89 ± 2. All professional pitchers returned to the same level of play. No significant differences existed between any preoperative and postoperative performance metrics for pitchers ($P > .05$).
Conclusion: Repair of LD and TM tears in both professional and recreational athletes produces reliable functional recovery with minimal pain and the ability to return to preoperative athletic activity, even among elite throwing athletes.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Latissimus dorsi; teres major; tear; overhead athlete; repair; pitcher; Major League Baseball (MLB)

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Overhead throwing exerts large forces on the glenohumeral joint and the surrounding musculature.[5] Avulsion injuries to the latissimus dorsi (LD) and teres major (TM) tendons are uncommon injuries, most commonly seen in high-level

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athletes.[15] Because of their relative rarity and nonspecific examination findings, these injuries can be difficult to diagnose, and many are missed on initial presentation. Furthermore, there are limited case reports and case series in the literature describing functional outcomes after LD or TM tears,[11,17-19] and there is a dearth of evidence-based guidelines for care of these injuries.[15] Most commonly, these injuries occur in specific competitive sports participants including water skiers, rock climbers, and overhead athletes, specifically professional baseball pitchers.[10,11,18]

The LD and TM muscles are strong internal rotators and are most active during the late cocking and acceleration phases, with slightly less activation seen in the deceleration phase of the pitching cycle.[19] These muscles are thought to be important for translating force from the lower extremity and trunk to the humerus and are thus important for protecting the shoulder from excess shear and for velocity creation. While the primary function of these muscles is in humeral adduction, extension, and internal rotation, the main function during the overhead pitch is to protect the anterior aspect of the glenohumeral joint. Hence, with a tear involving the LD or TM, many pitchers may not be able to continue to compete at a high level with nonoperative measures.

The overarching literature to date is composed of case reports describing outcomes after LD or TM repair.[2,3,6,7,10,11,18] Historically, several authors have suggested that nonoperative care is the best strategy in treating athletes with LD or TM avulsion injuries.[12,14,17] Among recreational athletes, nonoperative management may still result in satisfactory clinical outcomes without measurable functional limitations.[13,18] In some cases, this strategy may lead to a delay in return to sport (RTS), decreased athletic performance, or an inability to return to preinjury sporting activity. Conversely, other authors have shown that primary tendon repair may be indicated for elite athletes to restore native anatomy, restore shoulder strength, and potentially, achieve superior functional outcomes.[4,19] The goal of this approach is to return the high-level athlete to competitive sports in a timely manner.

Previously described techniques include a single-incision technique[13] and 2-incision technique for tendons retracted by over 5 cm to allow for direct repair.[4] This may be especially important in pitchers in whom the LD or TM tendons have been shown to be more active during the (early) acceleration phase of throwing.[5,8] There have been previous reports on an updated 2-incision technique for retracted tears,[9] as well as an isolated case of a Major League Baseball player treated with primary anatomic repair.[4] No previous studies in the literature have examined outcomes in a larger group of patients with longitudinal follow-up. Therefore, the objective of this study was to determine the outcomes and RTS rate after primary anatomic repair of isolated or combined LD and TM tendon tears in a group of elite athletes. We hypothesized that there would be a high rate of RTS following repair of the LD and/or TM in this select cohort and there would be no difference in performance after surgery compared with before the injury.

Methods

The surgical database of a single shoulder and elbow fellowship-trained surgeon was reviewed from January 1, 2010, until June 6, 2016, to identify patients undergoing LD and/or TM repair. A start date of 2010 was used because this was the first year the senior author performed this surgical procedure. Patients were included if they had undergone surgery more than 12 months earlier. Surgical data were retrospectively reviewed, although no subjective or baseline clinical data were available prior to surgery. All patients underwent examination with a standard series of shoulder radiographs (anteroposterior, lateral, oblique), as well as either magnetic resonance imaging (MRI) or magnetic resonance arthrography, to confirm the diagnosis of an LD and/or TM tear (Fig. 1, *A*). The surgical database was queried for Current Procedural Terminology code 23410 to identify all patients. A total of 13 patients were identified, 11 of whom had undergone surgery more than 1 year earlier. The electronic charts of patients who underwent repair of the LD and/or TM were reviewed to determine the following: patient age both at surgery and currently, gender, hand dominance, laterality, date of injury, time from injury to surgery, date of surgery, side injured (right or left), whether the injury was traumatic or atraumatic, mechanism of injury, sport played (if any), level of sport played (ie, high school, collegiate, professional, or recreational), postoperative range of motion (ROM), and complications.

Surgery was indicated if conservative treatment had failed and patients had a history and physical examination findings (loss of accuracy and velocity, pain during the late cocking and/or early acceleration phases, palpable defects, and tenderness over the LD or TM), as well as MRI or magnetic resonance arthrography findings, consistent with an LD and/or TM tear. Patient charts and operative notes were reviewed to obtain any reports of intraoperative or postoperative complications. Patients with working phone numbers on file who had undergone surgery more than 12 months earlier were then contacted by phone. Twelve months was chosen because we considered this to be an ample amount of time for all patients to RTS. Preoperative clinical scores were not available for these patients. Patients were asked about their ability or inability to RTS, their function on RTS (same, better, or worse than prior to surgery), and any complications they experienced. The following scores were obtained through questioning: Kerlan-Jobe Orthopaedic Clinic (KJOC) shoulder and elbow score, visual analog scale (VAS) pain score, and American Shoulder and Elbow Surgeons (ASES) shoulder score. The KJOC score has been validated for use in person, where the respondent places an X on a line that is 10 cm long. The examiner measures the distance from the far left of the scale (which is 0) to the respondent's mark and records this distance to the nearest millimeter. This is then converted to centimeters (eg, 75 mm would be converted into a score of 7.5 cm), and the scores from all questions are added up. Because patients were contacted by phone and did not return to the clinic to complete the survey, they were asked to quantify their answer from 0 to 100, and the answer was divided by 10 to obtain the score for each question (eg, an answer of 85 would yield a score of 8.5). Hence, this represents a modification of this score. The lead author (A.A.R.) personally made each phone call and administered the questionnaire to each patient, so there was no variability in the way the questions were asked from patient to patient.

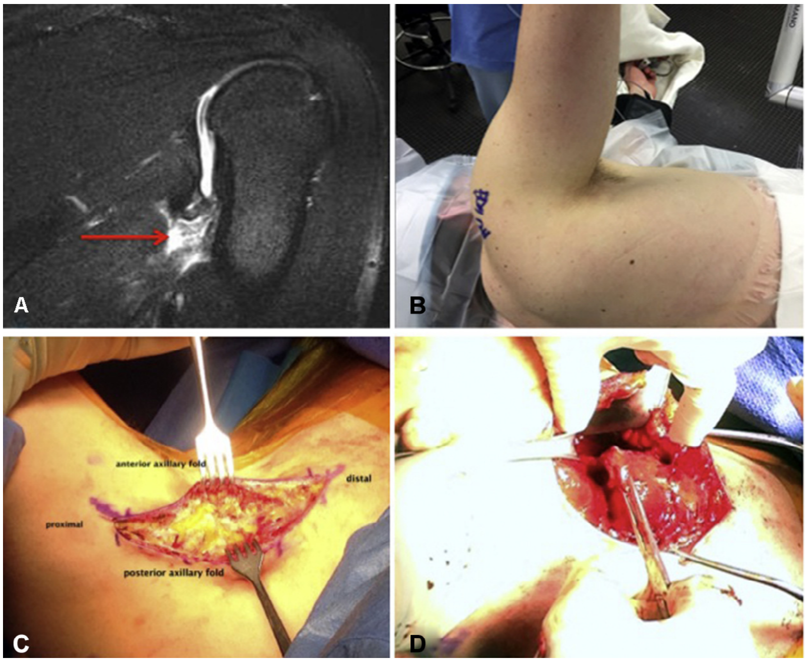

Figure 1 (**A**) Coronal magnetic resonance imaging of a right shoulder showing a retracted tear with significant fluid (*arrow*) around the latissimus dorsi and teres major. Depending on the characteristics of the tear, it sometimes can be best visualized on the sagittal, axial, or coronal magnetic resonance image. (**B**) The patient has been placed in the lateral decubitus position for access to the right shoulder. A palpable latissimus dorsi and teres major tendon stump is present, with notable loss of the posterior axillary fold. (**C**) Curvilinear hockey-stick incision overlying the posterior axillary fold. (**D**) Identification and mobilization of the ruptured latissimus dorsi and teres major tendon for primary repair.

Statistical analysis

Descriptive statistics were calculated and are presented as arithmetic mean ± standard deviation. Kolmogorov-Smirnov testing was performed to determine data normality. Preoperative and postoperative continuous variables were compared using paired Student *t* tests and Wilcoxon signed rank tests as appropriate. Our cohort was first considered as a complete group, and then pitchers were considered as a separate cohort. All analyses were conducted in Excel 2016 (Microsoft, Redmond, WA, USA) and SPSS (version 23; IBM, Armonk, NY, USA). Because a LD and/or TM tear is a rare injury addressed through a retrospective analysis, all available patients were included and no a priori power analysis was conducted.

Surgical technique

After regional anesthesia and intubation, the patient was positioned in the lateral decubitus position with use of a beanbag, axillary roll, and adjustable shoulder positioner (Trimano; Arthrex, Naples, FL, USA). Preoperative examination confirmed a palpable deformity and loss of normal posterior axillary contour (Fig. 1, *B*). After preparation and wide draping of the sterile field, the operative extremity was placed in the arm holder in an inverted position with the radial border of the forearm directed toward the floor. With the shoulder in 90° of abduction and elbow in 90° of flexion, the forearm was placed in maximal pronation with the shoulder internally rotated during dissection.

A curvilinear, hockey-stick incision was demarcated on the posterior aspect of the axillary fold overlying the palpable defect and retracted muscle belly. After local field infiltration with 1% lidocaine with epinephrine, a 5- to 8-cm incision was developed with careful dissection through the subdermal fat to avoid cutaneous nerve branches (Fig. 1, *C*), including the posterior brachial cutaneous nerve. Sharp dissection was used to identify and separate the retracted tendon stump from the neotendon, reactive scar tissue, and seroma cavity while preserving the epimysium of the involved LD and/or TM muscle belly. Once adequately mobilized (Fig. 1, *D*), the extremity was maximally positioned in internal rotation to allow exposure of the humeral insertion on the medial aspect and floor of the intertubercular groove. A large Chandler retractor was placed posteriorly on the humerus to retract the triceps and a pointed Hohmann retractor was placed anteriorly between the long head of the biceps and pectoralis major, while a thyroid or Richardson retractor was used at the distal apex of the incision. The bald, denuded footprint was gently prepared with a periosteal elevator and scored with a high-speed burr.

The 3.2-mm spade-tipped guide pin was then drilled in unicortical fashion at 8- to 10-mm intervals on the prepared footprint, allowing spacing for 2 to 3 endosteal buttons (Pec Button; Arthrex) preloaded with both high-tensile, No. 2 nonabsorbable suture (FiberWire; Arthrex) and 2-mm tape (FiberTape; Arthrex). By use of the threaded button inserter, the button was pushed into the prepared pilot hole while toggling traction was applied on the attached sutures to deploy the endosteal button. These buttons are all placed in a unicortical manner. After the inserter was removed, stability was assessed through axial traction and 1 limb of the high-tensile suture was prepared in a locking Krackow configuration on the respective aspect of the tendon. The opposite limb of this suture was then passed from the deep aspect of the tendon and served as the post suture for delivering the tendon to its attachment using the

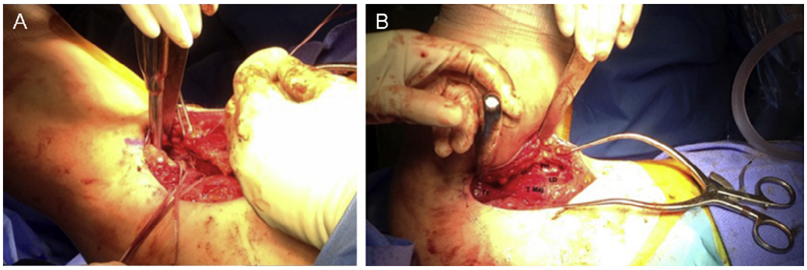

Figure 2 (**A**) Reduction of the tendon to the humeral insertion site using a tension-slide technique and endosteal button fixation. (**B**) Completed latissimus dorsi (LD) and teres major (T Maj) repair with restoration of anatomic posterior axillary fold. PM, pectoralis major; Tz, trapezius.

tension-slide technique.[20] This process was repeated for the high-tensile tape for additional security, and subsequent buttons were prepared in similar fashion. Once all sutures were passed, the marked post limbs were sequentially tensioned into place (Fig. 2, *A*), tied using standard knot-tying technique, and cut short to prevent prominence. Restoration of the normal muscular contour and posterior axillary fold was confirmed (Fig. 2, *B*), and the arm was repositioned for wound closure. If possible, fascial layer closure was performed using No. 2-0 monofilament suture with care to avoid puckering of the axillary soft tissues. Dermal and subcuticular layers were closed in standard fashion, and topical skin adhesive was applied to create an impervious, watertight closure.

The postoperative rehabilitation course is conservative, with strict immobilization in a sling with a 4-inch abduction pillow (which places the shoulder in internal rotation) for 6 weeks, with progressive gentle pendulum exercises and passive ROM exercises initiated at 2 weeks. At 6 weeks, the sling is discontinued and passive and active ROM exercises are performed with light isometric and stretching exercises. Between 12 and 16 weeks, light overhead activities or throwing programs may be initiated, and return to full activity is delayed until at least 6 months postoperatively depending on tissue integrity, repair quality, and anticipated at-risk physical demands.[4]

Results

Eleven patients met the inclusion and exclusion criteria. All included patients were male patients, aged 29.9 ± 12.4 years. Eighty-six percent of the cohort was right hand dominant. In 86% of cases, the procedure was performed on the dominant side. Repair occurred within 6 weeks of injury in 36% of cases (n = 4) and more than 6 weeks after injury in 64% of cases (n = 7), with the mean time from injury to repair being 389 ± 789 days (range, 8-2555 days). Pitchers accounted for 73% of the cohort (n = 8); of the pitchers, 1 played at the collegiate level, 1 played within Major League Baseball, and 6 played at a minor league level of competition. Of the remaining patients, 1 sustained the injury while kite surfing, 1 while weight lifting, and 1 while wakeboarding.

Outcomes were generally excellent after LD and/or TM repair. At final follow-up, the VAS pain score was 0.7 ± 1.9, the ASES score was 100 ± 0, and the KJOC score was 93 ± 5. All patients returned to play at the same level. Active forward elevation was 179° ± 2°, external rotation in adduction was 86° ± 13°, external rotation in abduction was 93° ± 8.2°, and internal rotation in abduction was 65° ± 8°. No patients had any objective finding of weakness on physical examination at final follow-up.

The professional (major and minor league) pitchers had a mean total time participating in professional baseball of 6.6 ± 3.9 years, with 3.9 ± 2.3 years before surgery and 2.7 ± 1.8 years after surgery. The VAS pain score was 0.0 ± 0.0, the ASES score was 100 ± 0, and the KJOC score was 89 ± 2. All professional pitchers returned to the same level of play. Examining performance data, we found no significant differences between any of the preoperative and postoperative performance metrics (Table I). The preoperative and postoperative trends in earned run average, games played, and innings pitched are shown visually in Figure 3, Figure 4, and Figure 5, respectively. No complications were noted in any patients in this series, and no repeat surgical interventions were recorded.

Discussion

While many LD and TM tears have historically been managed nonoperatively, the results of this single-surgeon series clearly demonstrate excellent results following open repair of the LD and TM using endosteal button devices. Our hypotheses were confirmed as the RTS rate following repair was 100% and there was no significant difference in measured performance statistics for any patient in any performance metric after surgery.

The TM and LD have a confluent insertion on the proximal humeral shaft, with both tendons blending together.[1,16] Hence, it is difficult to isolate the TM and LD tendons at their insertion point, and tears of the tendons in this region are often considered to involve both the TM and LD. For this reason, tears of the LD and TM were grouped together for the purposes of this study. Prior reports on nonoperative management of these injuries in professional baseball players have collated patients in similar fashion.[19]

While the literature surrounding latissimus and TM tears is sparse, the largest studies to date have only reported on pitchers who have been successfully treated nonoperatively. Nagda et al[17] reviewed 16 professional baseball pitchers treated nonoperatively for their latissimus and TM tears and found

Table I Preoperative and postoperative performance data for professional pitchers included in cohort and *P* values for paired Student *t* test, as well as 95% CI of difference between preoperatively and postoperatively

Variable	Preoperative	Postoperative	*P* value	95% CI of difference
Innings pitched per season	68.8 ± 53.4	69.9 ± 38.7	.916	−25.2 ± 23.0
Innings pitched per game	3.7 ± 2	4.3 ± 2	.166	−1.6 ± 0.4
Games per season	17.5 ± 6.4	17.9 ± 6.8	.873	−6.3 ± 5.5
Wins per season	4.1 ± 4.4	4 ± 2.5	.945	−2.7 ± 2.9
Losses per season	3.6 ± 2.9	4 ± 2.8	.656	−2.5 ± 1.7
Earned run average per season	3.7 ± 1.1	4.1 ± 0.8	.413	−1.5 ± 0.7
Complete games per season	0.3 ± 0.4	0.4 ± 0.5	.502	−0.5 ± 0.3
Shutouts per season	0.1 ± 0.2	0.1 ± 0.2	.893	−0.2 ± 0.2
Saves per season	1.3 ± 2.3	0.4 ± 0.6	.243	−0.8 ± 2.7
Hits per season	64.7 ± 48.8	65.9 ± 43.3	.901	−22.6 ± 20.3
Runs per season	31.2 ± 21.8	34.2 ± 21.5	.353	−10.3 ± 4.3
Home runs per season	4.9 ± 6.3	6.7 ± 5.2	.092	−4.0 ± 0.4
Walks per season	23.7 ± 16.6	25.4 ± 12.1	.752	−14.3 ± 10.9
Hits batted per season	3.1 ± 1.9	3.9 ± 3.9	.566	−3.8 ± 2.3
Strikeouts per season	63.9 ± 50	54 ± 29.2	.32	−12.4 ± 32.2
Walks and hits per innings pitched per season	1.3 ± 0.1	1.3 ± 0.3	.972	−0.3 ± 0.3

CI, confidence interval.

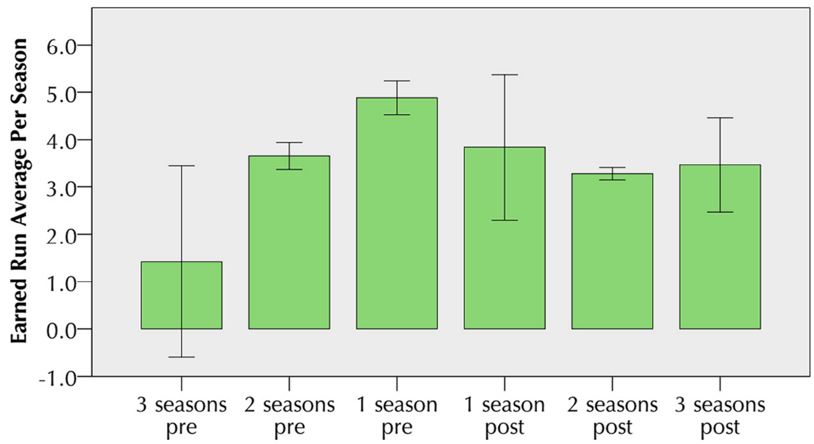

Figure 3 Mean earned run average per season (± standard deviation) for professional pitchers within the cohort for the 3 seasons played before (pre) and after (post) latissimus dorsi and/or teres major repair.

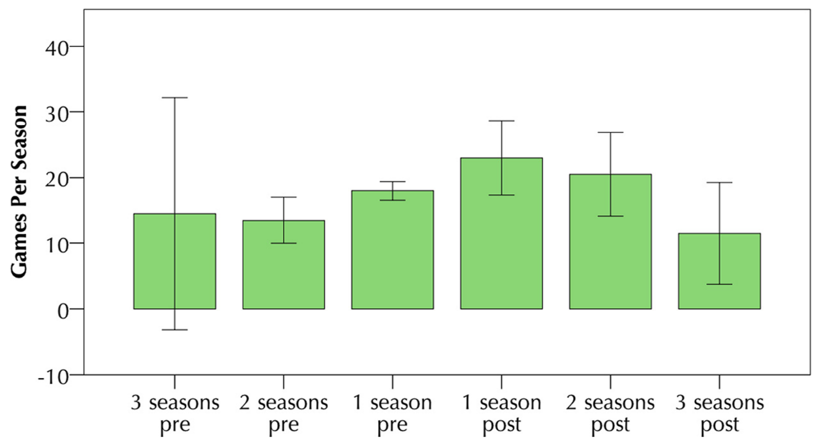

Figure 4 Mean games per season (± standard deviation) for professional pitchers within the cohort for the 3 seasons played before (pre) and after (post) latissimus dorsi and/or teres major repair.

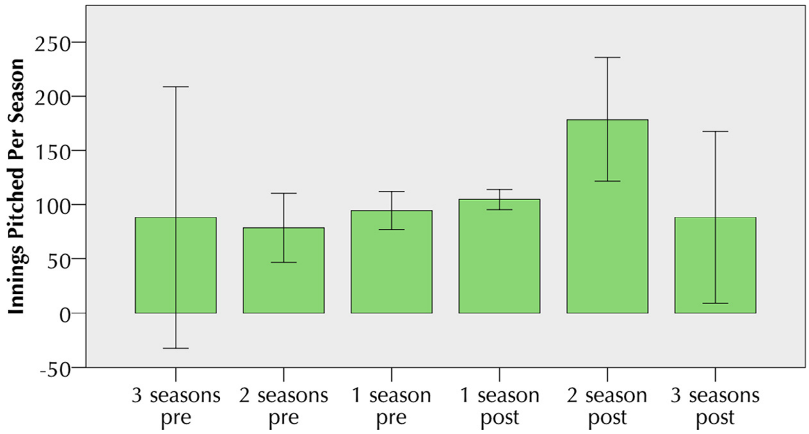

Figure 5 Mean innings pitched per season (± standard deviation) for professional pitchers within the cohort for the 3 seasons played before (pre) and after (post) latissimus dorsi and/or teres major repair.

that 94% were able to RTS at the same level or a higher level. Schickendantz et al[19] reviewed 10 professional baseball pitchers treated nonoperatively for a latissimus and/or TM tear and found that 90% were able to RTS 3 months from the date of injury, with 1 player unable to return to the same level of competition. Hence, the literature suggests that a trial of nonoperative treatment is warranted in athletes who sustain an LD and/or TM tear. However, when athletes cannot RTS at the same level following a course of nonoperative treatment, surgical intervention should be offered. In our study, a course of nonoperative treatment, including rest and rehabilitation, and a return-to-throwing program had failed in most athletes, as the average time to surgery was over 1 year from the date of injury, and they were still able to RTS at a high level. Therefore, on the basis of the results of this and prior studies, as well as the experience of the senior author, for athletes who sustain an LD or TM tear that is retracted less than 3 cm, we recommend an initial 3- to 6-month trial of nonoperative treatment. If the tear is retracted more than 3 cm, earlier intervention with direct surgical repair is recommended. If these athletes are unable to return to play following the nonoperative period, we recommend surgical repair of the LD and/or TM, with an expected RTS rate of more than 90%. On the basis of the results of this study, those patients with chronic tears were able to RTS, so while an acute repair is often technically less demanding and offers a good chance for successful recovery, chronic tears can also be addressed with excellent outcomes.

This study found that professional pitchers, as well as recreational athletes, who sustained latissimus and TM tears were able to successfully RTS at a high level without any significant decline in performance. In the prior studies that evaluated latissimus and TM tears in professional baseball pitchers, specific performance data were not analyzed.[17,19] Hence, it is unclear whether these pitchers were as effective after nonoperative management of their tear as they were before their injury. A recent systematic review of the treatment of latissimus and TM tears in professional athletes only identified 30 patients in the literature who had been treated for this problem, 29 of whom were treated nonoperatively.[15] The authors found a shorter RTS time in the nonoperatively treated patients compared with the 1 operatively treated patient (100 days vs 140 days) but found a 17.2% rate of complications and/or setbacks in the nonoperatively treated pitchers whereas the operatively treated patient had no issues. This finding is similar to the findings of our study, in which no complications were seen. Because the results of both nonoperatively and surgically treated LD and TM tears are encouraging, we recommend a 3- to 6-month period of nonoperative treatment followed by surgical repair in patients who are unable to return to their prior level of play following the trial of nonoperative treatment. As always, treatment should be individualized to the goals and expectations of each patient, and high-level athletes with time constraints may elect to undergo surgical intervention earlier. Care should be taken when discussing nonoperative versus operative treatment plans with patients because it is currently unclear which treatment option should be offered to each patient. Treatment plans should be individualized to each patient.

Limitations

Although this is the largest single-surgeon series of LD and TM repairs in the literature, there are several limitations that must be acknowledged. This was a retrospective review and is subject to all limitations of a retrospective study. No consistent preoperative clinical data were available for our patients, so although their results were encouraging, a comparison with their preoperative scores was not possible. We were not able to have the patients return to the clinic at the time of this study for a final follow-up examination and so relied on the last clinic note, as well as a phone interview, to determine the patients' current status and their functional outcome scores. This could have introduced bias into the results. No follow-up MRI scans were performed to assess the integrity of the repair as all patients were functioning well. Hence, the actual tendon healing rate is unclear. Furthermore, this series of patients was limited to a single, skilled shoulder and elbow fellowship-trained surgeon. As such, the results may not be translatable to all surgeons, patient populations, and surgical techniques.

Conclusion

Repair of LD and TM tears in both professional and recreational athletes produces reliable functional recovery with minimal pain and the ability to return to preoperative athletic activity, even among elite throwing athletes.

Disclaimer

Brian R. Waterman has the following disclosures: *American Journal of Orthopedics* and *Arthroscopy*—editorial board or governing board; Arthroscopy Association of North America and Society of Military Orthopaedics Surgeons—board or committee member; and Elsevier—publishing royalties and/or financial or material support.

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