Original Research

Postoperative Rehabilitation and Return-to-Sport Criteria After Distal Triceps Rupture Repair

A Scoping Review

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Background: Distal triceps rupture is a rare injury that is commonly surgically repaired to improve elbow strength and function. Most patients are active and have goals to return to specific activities and sports. There is no gold standard rehabilitation protocol for return to sport (RTS) after distal triceps repair.

Purpose: To identify in the literature any criteria used for RTS after distal triceps repair.

Study Design: Scoping review; Level of evidence, 4.

Methods: Under PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, level 1 to 4 studies that examined distal triceps repair and had a minimum follow-up duration of 12 months were deemed eligible for study inclusion. Exclusion criteria encompassed studies that employed nonoperative treatment, lacked specific RTS criteria, or involved revision cases. The selected studies underwent assessment regarding RTS outcomes, timelines, rates, and methodological quality.

Results: Of the initial 378 unique studies, 6 studies (including 116 patients involved in 16 different sports) met the inclusion criteria. Four of the studies reported RTS rates, with a mean of 89.3%. The duration of time for returning to sport was reported in 2 studies and varied from 4 to 6 months. The parameters most emphasized in the rehabilitation protocols were progressive range of motion exercises, followed by early immobilization and progressive strengthening exercises. Supervised therapy was reported in only 2 (33%) studies. Although all studies included a rehabilitation protocol and 5 studies included a timeline for RTS, only 1 study provided subjective criteria, and no studies utilized specific objective measurement criteria. The overall study quality was fair.

Conclusion: This review demonstrated that the overall RTS rate after distal triceps repair was high (89.3%), with no consensus on RTS criteria. Most studies included initial immobilization followed by progressive range of motion and strengthening. Timing after surgery was used as a measure to RTS in the minority of studies and varied between 4 and 6 months. Further research is needed to develop functional and performance-based metrics to better standardize RTS criteria and rehabilitation protocols.

Keywords: distal triceps rupture; distal triceps repair; return-to-sport criteria; rehabilitation

The triceps muscle plays a crucial role in elbow extension and overall upper extremity function. It consists of 3 heads: the long head, the lateral head, and the medial head. The triceps tendon, formed by the convergence of these 3 heads, attaches to the olecranon process of the ulna, providing stability and power during activities involving elbow extension. Rupture of the distal triceps tendon can significantly affect an individual's functionality and athletic performance.[15]

Distal triceps tendon ruptures, although relatively uncommon, predominantly affect active and middle-aged individuals, often occurring due to sudden forceful contractions against resistance or direct trauma to the elbow joint.[4,6,11,16,20] Additionally, use of both anabolic steroids and prior injection of local corticosteroid is a known risk factor for rupture.[18,19] The incidence of distal triceps

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tendon ruptures has been reported to be <1% of all tendon injuries.[3] Surgical options for repair include various techniques such as direct tendon-to-tendon repair, transosseous tunnels, and suture anchor fixation. The choice of surgical technique depends on such factors as the extent of the injury, patient characteristics, and surgeon preference.[3,5,7,9,10] However, an essential consideration in the treatment of distal triceps tendon ruptures is the patient's ability to return to sports (RTS) and other physical activities postoperatively. Understanding the relationship between surgical options and their impact on RTS outcomes is crucial in optimizing the management of these injuries.[1,2,14,21]

The purpose of this study was to review the existing literature on distal triceps tendon rupture and surgical repair. Specifically, the aim was to evaluate the postoperative rehabilitation parameters and criteria used to determine RTS. We hypothesized that the majority of studies would primarily employ time-based criteria rather than performance-based or objective functional data to guide the RTS decision-making process.

METHODS

Search Strategy

The review was developed and reported in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and registered in PROSPERO (Prospective Register of Systematic Reviews). A literature search was performed using PubMed, CINAHL, MEDLINE, SPORTDiscus, and Cochrane databases from inception to March 2022. A review of evidence level 1 to 4 studies was conducted for patients who underwent distal triceps rupture surgical intervention. The search criteria included a variation of triceps tendon, distal triceps rupture, repair, reconstruction, surgery, rehabilitation, RTS, and return to play. After the studies were reviewed for inclusion criteria, an additional search of references was performed to identify any additional articles that were missed during initial inclusion.

A review of the initial search was independently performed by 2 orthopaedic residents (B.M.P. and A.G.). The selection was then unblinded, and any discrepancies in inclusion between the reviewers were settled by the senior author (R.A.J.). Consensus was reached in all cases. Data were then extracted from the studies that met the inclusion criteria.

Eligibility Criteria

Studies that met inclusion criteria included those in which patients had surgical intervention for their distal triceps tendon rupture and >1 year of follow-up; the studies were in the English language. Studies that were excluded included those in which distal triceps tendon rupture was treated nonoperatively; those that lacked explicit rehabilitation protocol or RTS criteria; those that included only patients with concomitant injury or revision procedures; or that were cadaveric or biomechanical studies, review articles, or abstracts.

Quality of Literature Methodology

The modified Coleman Methodology Score (MCMS) was used to assess the methodological quality of all included studies. This was independently completed by 2 orthopaedic residents (B.M.P., A.G.). The MSCS assesses study methodology based on 10 criteria, with a total score ranging from 0 to 100. Scores <55 are considered poor quality, 55 to 69 fair, 70 to 84 good, and 85 to 100 considered excellent quality. Each subsection of the MCMS is based on the CONSORT (Consolidated Standards of Reporting Trials) statement. In addition, we evaluated the value of the RTS criteria specifically for each article using the assessment presented by Zaman et al,[22] which involves assigning scores in 4 categories: rehabilitation protocol, timeline for return to activity, objective/subjective criteria, and specific measurement criteria. The maximum possible score on this scale is 4.

Data Extraction and Statistical Analysis

Number of patients, patient demographics, sport played, injury setting, level of play, hand dominance, surgical technique, rehabilitation protocol, RTS time, postoperative level of play, follow-up duration, and complications were extracted from the included studies. All data were analyzed using Microsoft Excel and reported via descriptive percentage measures. Meta-analysis was not possible due to limitations in data standardization and study design heterogeneity. Patient-reported outcomes were not reported due to variety in the surveys between included studies.

RESULTS

After the initial search and removal of duplicates, a total of 378 published articles were identified. After the application of inclusion and exclusion criteria, 6 studies[2,5,8,9,12,13] were deemed suitable for the final analysis (Figure 1).

There were 2 studies[2,13] that focused exclusively on patients engaged in sports activities, while the remaining

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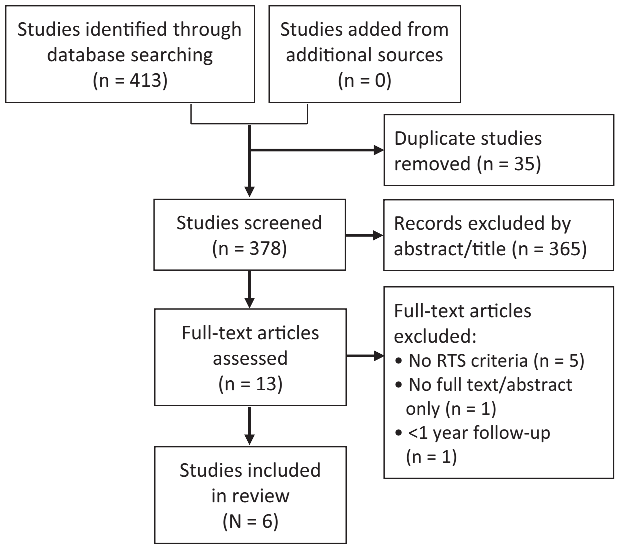

Figure 1. PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) flowchart diagram for the study-inclusion process. RTS, return to sports.

4 studies[5,8,9,12] included both athletes and nonathletes. Since the data did not differentiate between these groups, the entire population from each study was considered. Athletes were considered those who reported playing some type of sport at any level, including recreational, competitive, and professional levels. Three studies[8,12,13] included some patients with concomitant elbow injuries that did not meet the inclusion criteria for this review. In these studies, the outcomes were reported on individual patients, so the data were separated out for the patients who did not meet inclusion criteria. Only patients who met inclusion criteria were included in the final analysis; in total, there were 116 patients included. Tear location, description of tear, and surgical techniques used are listed in Table 1. Although specific sports were not consistently reported across most studies, injuries were observed across multiple sporting activities (Table 2). No studies provided information on the initial level of play (eg. recreational, professional). Four studies[2,9,12,13] included RTS rates. Only 2 studies[2,13] investigated whether patients were able to return to their previous level of play after the operation. All of the included studies had an evidence level of 4.

Quality Assessment

The study quality as assessed by the MCMS was determined to be fair, with a score of 55 ± 3.3 (Table 3). All the included studies reported satisfactory certainty in diagnosing the condition, outlined post-operative rehabilitation procedures, and maintained sufficient follow-up throughout the study period. Most studies included adequate details of the operative techniques. However, most studies had small sample sizes, and multiple surgical techniques were used with combined results.

Parameters of Postoperative Rehabilitation

All 6 studies provided some level of detail regarding the parameters of postoperative rehabilitation; a summary of these protocols can be found in Table 4. The rehabilitation protocols were assessed based on 5 main components. Five studies[5,8,9,12,13] (83%) implemented a period of cast or splint immobilization lasting 2 to 6 weeks. Agarwalla et al[2] did not include a period of strict immobilization but did place the patient in a hinged elbow brace with flexion limited to 20° for the first 2 weeks. Progressive range of motion (ROM) exercises were included in all studies, although the duration of the phase varied across the studies. Five studies[2,8,9,12,13] (83%) included some amount of strength training. None of the studies specified sport-specific rehabilitation protocols, although Agarwalla et al[2] did mention that patients were given progressively more difficult exercises until full strength was achieved and that patients were allowed to RTS only after sufficient ROM and strength were attained. However, there were no specifics on what the exercises were, and no definition for what was meant by sufficient ROM and strength. Two studies[8,13] (33%) referenced a supervised physical therapy program, although it is likely other studies utilized one but did not mention it in their postoperative rehabilitation.

RTS Criteria

Time From Surgery. Table 5 presents the RTS timelines as outlined in the studies. Three of the 6 studies[5,8,12] included a recommended time for RTS within their rehabilitation protocols. However, only 2 studies[2,13] (33%) reported the actual RTS timing. Agarwalla et al[2] was the only study to include a recommended timeline based on return of sufficient strength and ROM for the desired sport.

Conditional RTS Criteria. The articles were thoroughly examined to identify any criteria, whether subjective or objective, that were considered barriers to participation in sports and continued therapy. Agarwalla et al[2] was the only study with any criteria reported, and these were subjective in nature. None of the studies included any objective measures or parameters.

Specific Measurements for RTS. The studies did not include any reports regarding the utilization of specific clinical measurements, such as specific ROM or strength requirements, as criteria. Furthermore, no imaging assessments were employed in the studies.

Assessment of Value. A rehabilitation protocol was reported in all of the studies. Timeline for return to activity was reported in 4 studies[2,5,8,12] (66.7%). Agarwalla et al[2] was the only study to include some objective/subjective criteria for RTS. None of the studies provided information on specific measurement criteria. Further, none of the studies achieved a perfect score of 4, indicating a lack of comprehensive definition for RTS criteria. The scores assigned to each article can be found in Table 6, with a mean score of 1.8.

Rate of RTS. Four studies[2,9,12,13] included in the analysis reported the rate of RTS (Table 1). The overall RTS

TABLE 1
Distal Triceps Tendon Rupture Characteristics According to Study[a]

	Agarwalla et al[2]	Bava et al[5]	Giannicola et al[8]	Hall et al[9]	Kose et al[12]	Lempainen et al[13]
Total study population (n=116)	68	5	22	7 (5 athletes)	5 (2 athletes)	9
Tear location						
Tendon insertion	40	0	0	0	0	0
Tendon avulsion	25	0	0	0	5	3
Myotendinous	0	0	0	0	0	6
Not reported	3	5	22	7	0	0
Tear description						
Partial	41	0	5	4 (2 athletes)	0	6
Full	27	5	17	3 (3 athletes)	5	3
Technique						
Transosseous bone tunnel	25	0	17	7	5	0
Suture anchor	18	5	5	0	0	3
Direct suture	25	0	0	0	0	6
Return to sport	61	NR	NR	4	2	8

[a]Values are presented as No. of patients. NR, not reported.

TABLE 2
Distribution of Sports in the Included Studies

Sports Included in the Patient Population	No. of Studies
Not reported	3
Baseball	1
Football	1
Softball	1
Lacrosse	1
Golf	2
Basketball	1
Hockey	1
Soccer	2
Swimming	1
Running	1
Weightlifting	4
CrossFit	1
Cycling/Biking	2
Yoga	1
Boxing	1
Fishing	1

rate was 89.3%. In the study by Agarwalla et al,[2] the largest study incorporating multiple sports, the overall RTS rate was reported as 89.7%, with 61 of 68 participants returning to some level of sport. Their study also looked at the level of RTS, with 3 athletes returning to a higher level of sport (4.4%), 41 to the same level (60.3%), and 24 to a lower level (35.3%).[2] Kose at al[12] had 2 athletes included, and both were able to return to the same level of preoperative play. Lempainen et al[13] included 9 athletes, of whom 8 were able to RTS; 4 returned to their previous level of play and 4 to a lower level of play. Of note, patients with both myotendinous tears and avulsions from the olecranon were included in their study. Those with avulsion injuries did better postoperatively, with all returning to previous level of play while in the myotendinous group, only 1 returned to previous level of play. Multiple techniques were utilized in the studies; however, the patient RTS outcomes were not broken down by technique, so analysis by technique was unable to be performed.

DISCUSSION

The rehabilitation protocols primarily highlighted progressive ROM exercises, with early immobilization and progressive strengthening exercises also receiving emphasis. While all studies incorporated a rehabilitation protocol and 5 outlined an RTS timeline, subjective criteria were provided by only 1 study, and none utilized specific objective measurement criteria. Our hypothesis was confirmed; 83% of studies employed time-based criteria rather than performance-based or objective functional data to guide the RTS decision-making process.

The results of this review underscore the importance of establishing a validated rehabilitation and RTS protocol. Although all the studies incorporated some sort of immobilization or stabilization with brace followed by progressive ROM, the primary determinant for allowing RTS was based on time. Only 2 studies[2,13] reported actual RTS times, with variations in this timeline ranging from 4 to 6 months.

Progressive ROM parameters have long been integral to the postoperative rehabilitation of tendon repairs. Traditionally, a period of immobilization prior to initiating ROM exercises has been employed in these repairs to allow soft tissue rest. Of the 6 included studies, 5 studies[5,8,9,12,13] implemented strict immobilization for around 2 weeks before transitioning to progressive ROM. Agarwalla et al[2] did not splint or cast but did place patients in a brace limited to 20° of motion for the first 2 weeks postoperatively. Additionally, all studies[2,5,8,9,12,13] included some ROM exercises before returning to some level of strengthening or resuming full activity. Agarwalla et al[2] was the only study large enough to perform additional multivariate analysis; they found that there was no correlation between

TABLE 3
Modified Coleman Methodology Score for Each Study

	Item[a]										
	1	2	3	4	5	6	7	8	9	10	Total[b]
Agarwalla et al[2]	7	10	0	0	5	10	5	10	11	0	58
Bava et al[5]	0	4	10	0	5	10	5	7	11	5	57
Giannicola et al[8]	0	4	7	0	5	10	5	7	11	5	54
Hall et al[9]	0	7	10	0	5	10	5	7	11	0	55
Kose et al[12]	0	4	10	0	5	10	5	7	11	5	57
Lempainen et al[13]	0	7	7	0	5	5	5	4	11	5	49

[a]Key to items: 1 = Study size (10 points): 2 = Percentage of patients with follow-up (10 points); 3 = Number of interventions per group (10 points); 4 = Study type (15 points); 5 = Diagnostic certainty (5 points); 6 = Description of surgical technique (10 points); 7 = Description of postoperative rehabilitation (5 points); 8 = Outcome criteria (10 points); 9 = Procedure for assessing outcomes (15 points); 10 = Description of patient selection process (10 points).
[b]Total out of 100 points.

TABLE 4
Postoperative Rehabilitation Parameters in the Included Studies

Rehabilitation Parameter	No. of Studies
Cast/splint immobilization	5
Range of motion exercises	6
Strengthening	2
Supervised physical therapy	2
Multiphase program	3

TABLE 5
Return-to-Sport Timeline by Study[a]

	Recommended RTS Timeline	Reported RTS Timeline
Agarwalla et al[2]	After sufficient ROM and strength attained	5.9 ± 4.4 mo
Bava et al[5]	5-6 mo	NR
Giannicola et al[8]	6 mo	NR
Hall et al[9]	NR	NR
Kose et al[12]	6 mo	NR
Lempainen et al[13]	NR	4-6 mo

[a]NR, not reported; RTS, return to sport.

age at the time of surgery, sex, degree of tear, location of tear, mechanism of injury, operative technique, symptom duration, or surgery on the dominant extremity on RTS at the same level. Increasing body mass index was the only negative predictor of return to previous level of sport.[2] Theirs is the only study to our knowledge that was able to perform this type of clinical analysis. However, their study included multiple techniques and multiple sports, so further research is needed on specific techniques and individual sports.

Our review demonstrated a number of different techniques described in the literature, including direct tendon-to-tendon repair, suture anchor fixation, and transosseous tunnels. While the existing literature lacks comprehensive RTS protocols and criteria, recent studies have focused on identifying the most biomechanically effective surgical fixation methods for distal triceps repair. Carpenter et al[7] performed a biomechanical comparison of transosseous suture repair versus knotless double-row suture anchor repair using equal suture constructs in 20 cadaveric elbows. They demonstrated that there was no difference between the repair techniques at 1500 cycles on the medial or lateral side of the repair.[7] Scheiderer et al[17] performed a comparative biomechanical analysis on 24 cadaveric elbows using 3 different techniques: the gold standard transosseous cruciate repair technique, knotless suture-

TABLE 6
Scoring Report for RTS Value Assessment[a]

	Category				
	Rehabilitation Protocol	Timeline for Return to Activity	Objective/Subjective Criteria	Specific Measurement Criteria	Overall Score
Agarwalla et al[2]	1	1	1	0	3
Bava et al[5]	1	1	0	0	2
Giannicola et al[8]	1	1	0	0	2
Hall et al[9]	1	0	0	0	1
Kose et al[12]	1	1	0	0	2
Lempainen et al[13]	1	0	0	0	1

[a]Assessment criteria according to Zaman et al.[22] A maximum of 1 point was given per category if the study met the criteria. RTS, return to sport.

bridge repair, and a novel V-shaped tendon repair technique that more closely matches the native tendon insertional anatomic footprint on the olecranon. They found that the suture anchor and V-shaped tendon repair techniques provided better anatomic footprint coverage and that the ultimate load to failure was highest with the V-shaped tendon repair technique. Gap formation during load cycling was similar in the anchor and V-shaped tendon repair and significantly greater in the gold standard transosseous repair group.[17] Their study may give some insight into when a more aggressive rehabilitation program can be utilized for athletes wanting to RTS at a sooner date.

Professional sports teams, team physicians, and sports training personnel, including athletic trainers and physical therapists, in our opinion, are likely to possess more nuanced and sport-specific RTS rehabilitation protocols than those currently published. However, a limitation in the field remains the scarcity of published protocols and specific RTS criteria focused on objective metrics. The studies included in this review had a mean RTS value rating of 1.8, with only 1 study[2] including 3 of the 4 metrics. None of the studies included any objective metrics or specific measurement criteria. Although the included studies demonstrated a relatively high RTS rate (89.3%), the rate of returning to the same or higher level of performance postinjury was lower. Agarwalla et al[2] reported an RTS rate at the same or higher intensity of only 64.7% and a return to a lower level of 35.3%. Similarly, Lempainen et al[13] found that while the overall RTS rate and return to preoperative level of play was 88.8%, RTS at the same level without any lingering symptoms postoperatively was only 44.4%.

As distal triceps ruptures are relatively rare, there are few reports in the literature regarding RTS at a high level. Mair et al[14] reviewed RTS outcomes in the National Football League over a period of 6 years (1991-1996). A total of 21 injuries, partial and complete tears, were identified in 19 players, with 15 injuries undergoing surgery: 4 partial tears and all 11 complete tears. The most common mechanism of injury was an eccentric load to the contracting triceps, and linemen were the most common players affected. The overall RTS rate after surgery was 93.3%.[14] Although their study demonstrated a high RTS rate among elite athletes, it is important to note that it was a retrospective review and that it does not provide insights into rehabilitation protocols or specific RTS criteria that can be extrapolated across different sports or levels of play. Further research is needed to investigate sport-specific protocols and determine whether varying protocols are necessary for competitive versus recreational RTS scenarios.

Limitations

There are multiple limitations to the current review. There were only 6 studies available for review, which is a small sample size. Additionally, the studies were retrospective in nature, and we did not include any randomized controlled trials focused on specific RTS criteria. Multiple operative techniques were included, and additional analysis was unable to be performed to determine how this affected overall RTS rates. Level of play was not reported in most of the included studies, which may have affected the RTS rate, timeline, and criteria, as recreational athletes likely have a more standardized RTS protocol while high-level athletes have more sport-specific RTS protocols. This review followed the methodology of previous studies focused on RTS criteria and excluded any published postoperative protocols that were not built on specific prospective or retrospective data. Additionally, multiple studies reported on patient-reported outcomes; however, as various patient-reported outcome measures were used, the decision was made not to include these in this review.

CONCLUSION

The overall RTS rate after distal triceps repair was found to be high (89.3%), with no consensus on RTS criteria. Most studies included initial immobilization followed by progressive ROM and strengthening. Timing after surgery was used as a measure for RTS in the minority of studies and varied between 4 and 6 months. Further research is needed to develop functional and performance-based metrics to better standardize RTS criteria and rehabilitation protocols.

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