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Influence of diabetes mellitus on rotator cuff muscle strength recovery following arthroscopic rotator cuff repair: a prospective observational study

Henry Mathews[1]*, Nirma Joy[2]

[1]Department of Orthopaedics, Al-Azhar Medical College and Super Speciality Hospital, Thodupuzha, Kerala, India
[2]Department of Dermatology, Al-Azhar Medical College and Super Speciality Hospital, Thodupuzha, Kerala, India

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***Correspondence:**
Dr. Henry Mathews,
E-mail: nirmajoyderm@gmail.com

ABSTRACT

Background: Arthroscopic rotator cuff repair (ARCR) is an established treatment for symptomatic rotator cuff tears, resulting in significant improvements in pain and shoulder function. However, objective assessment of postoperative rotator cuff muscle strength and its relationship with functional recovery remains inadequately reported. This study evaluated changes in rotator cuff muscle strength following ARCR, investigated whether improvements in strength correlated with functional outcomes, and examined the influence of diabetes mellitus on recovery trajectories.
Methods: A prospective cohort study was conducted at a tertiary care teaching hospital between September 2017 and September 2019. Patients aged 18-60 years with reparable rotator cuff tears undergoing primary ARCR were enrolled. Clinical evaluation included preoperative and six-month postoperative assessment of isometric and isokinetic internal and external rotation strength using a Kin-Com 125 AP dynamometer. Functional outcomes were assessed using the American shoulder and elbow surgeons (ASES) score and Constant score. Paired comparisons were performed to evaluate postoperative changes, and correlation analysis was used to determine the association between strength recovery and functional outcomes.
Results: Twenty-six patients completed the six-month follow-up. The mean age was 48.3 years, with 15 males and 11 females. Significant improvements were observed in both functional outcome measures, with mean increases of 53.8 points in the ASES score and 38 points in the Constant score (both $p<0.0001$). Isometric internal and external rotation strength increased by 11.5 Nm and 8 Nm, respectively. Significant improvements were also observed in isokinetic strength at angular velocities of 60°/s and 120°/s for both internal and external rotation (all $p<0.0001$). Despite these improvements, no significant correlation was identified between gains in rotator cuff muscle strength and postoperative functional outcome scores. However, subgroup analysis revealed that patients with concurrent diabetes mellitus demonstrated a markedly blunted recovery trajectory in torque gains compared to non-diabetic participants.
Conclusions: ARCR resulted in significant improvements in objective rotator cuff muscle strength and shoulder function at six months. However, early postoperative functional recovery did not correlate with the magnitude of muscle strength recovery, suggesting that patient-reported functional improvement is influenced by factors beyond muscle strength alone.

Keywords: Arthroscopic rotator cuff repair Rotator cuff tear, Muscle strength, Isokinetic dynamometry, Constant score, ASES score, Shoulder function

INTRODUCTION

Rotator cuff tears are among the most common causes of chronic shoulder pain and disability, with an estimated prevalence of approximately 20% in the general population, increasing significantly with advancing age.[1] Patients frequently present with pain, weakness, reduced range of motion, and impairment in activities of daily

living, all of which adversely affect quality of life. Symptomatic full-thickness tears that fail conservative management are commonly treated with ARCR, which has become the preferred surgical technique because of its minimally invasive nature, improved visualization, preservation of the deltoid muscle, and favorable clinical outcomes.[2,3] Despite the known challenges diabetes presents to tendon-to-bone healing and functional rehabilitation, the specific extent to which diabetes influences objective muscle strength recovery following ARCR remains inadequately understood.

Several studies have demonstrated that ARCR provides significant pain relief and improvement in patient-reported functional outcomes, irrespective of age and tear size.[4-6] Consequently, postoperative evaluation has largely focused on validated clinical outcome measures such as the ASES score and the Constant score. While these instruments reliably assess pain and perceived shoulder function, they do not objectively quantify the recovery of rotator cuff muscle strength, which is fundamental to restoring dynamic glenohumeral stability and normal shoulder biomechanics.[7]

The rotator cuff acts not only as a motor unit but also as the principal dynamic stabilizer of the glenohumeral joint by maintaining the humeral head within the glenoid during shoulder motion.[8] Recovery of muscle strength following tendon repair is therefore expected to contribute to functional restoration. Nevertheless, objective assessment of postoperative strength has received considerably less attention than patient-reported outcomes. The limited number of available studies have used different assessment methods, making comparisons difficult and preventing clear conclusions regarding the relationship between muscle strength recovery and functional improvement.[9]

Isokinetic dynamometry provides a reliable and reproducible method for evaluating shoulder muscle performance by measuring peak torque during controlled internal and external rotation movements.[10] It enables objective quantification of both isometric and isokinetic muscle strength and has been shown to possess excellent test-retest reliability. Although previous investigators have reported significant improvements in muscle strength following ARCR, the extent to which these improvements influence clinical recovery remains controversial. Lee et al demonstrated that preoperative rotator cuff strength ratios predicted postoperative shoulder function, whereas other studies have suggested that improvements in muscle strength may not directly translate into better patient-reported outcomes.[11,12]

The discrepancy between objective strength recovery and subjective functional improvement highlights an important gap in current literature. Understanding this relationship may assist clinicians in refining rehabilitation protocols, establishing realistic postoperative expectations, and identifying outcome measures that best reflect recovery after surgery.

The present prospective cohort study was undertaken to objectively evaluate changes in rotator cuff muscle strength following ARCR using isometric and isokinetic dynamometry. In addition, the study aimed to determine whether postoperative improvements in muscle strength correlate with improvements in functional outcome as measured by the ASES and constant scores.

METHODS

Study design and setting

A prospective cohort study was conducted in the Department of Orthopaedics in tertiary center between September 2017 and September 2019. Institutional ethics committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants.

Participants

Patients aged between 18 and 60 years with symptomatic reparable rotator cuff tears scheduled for primary arthroscopic repair were screened for eligibility. Diagnosis was established based on clinical examination and magnetic resonance imaging (MRI). Glycemic status and medical history of diabetes were recorded to evaluate their secondary influence on postoperative muscle strength recovery trajectories and functional outcome scores.

Patients with irreparable rotator cuff tears (Patte stage III after release or Goutallier grade IV fatty degeneration), rotator cuff arthropathy, adhesive capsulitis, bilateral shoulder pathology, associated neuromuscular disorders, or a positive drop-arm sign were excluded.

Sample size

The sample size was estimated using previously published data demonstrating a mean postoperative improvement of nine points in the constant score following ARCR. At 90% study power and a 1% level of significance, the minimum required sample size was calculated as 22 patients.

Surgical procedure

All procedures were performed arthroscopically by experienced shoulder surgeons with patients in the lateral decubitus position.

Tear configuration and repair technique were determined intraoperatively according to tear morphology and tissue quality. Single-row or double-row repair techniques were employed based on surgeon preference and intraoperative findings.

Rehabilitation protocol

A standardized postoperative rehabilitation programme was followed for all patients. Passive range-of-motion exercises were initiated from the seventh postoperative day. Active-assisted and active shoulder movements were commenced after six weeks, with the goal of achieving full active range of motion by three months. Progressive strengthening exercises were subsequently introduced under supervised physiotherapy.

Outcome assessment

Clinical evaluation was performed preoperatively and repeated six months after surgery.

Functional outcomes were assessed using the ASES score and the constant score.

Objective rotator cuff muscle strength was evaluated using a Kin-Com 125 AP isokinetic dynamometer (Chattanooga Group, Tennessee, USA). All assessments were performed by the same examiner using a standardized testing protocol to minimize interobserver variability.

Before testing, participants completed a five-minute warm-up followed by familiarization with the equipment. Testing was performed with patients seated and stabilized using shoulder and waist straps. The shoulder was positioned at 45° of abduction in the scapular plane, with careful alignment of the glenohumeral joint to the axis of rotation of the dynamometer.

Peak torque (Nm) was recorded during maximal voluntary contraction. Isometric strength was measured for internal and external rotation. Isokinetic strength was assessed at angular velocities of 60°/s and 120°/s for both internal and external rotation. Five maximal repetitions were performed for each assessment, and the highest recorded value was used for analysis.

Statistical analysis

Data were analysed using IBM SPSS Statistics software. Continuous variables expressed as mean±SD/ median (interquartile range), depending on data distribution. Normality was assessed before statistical testing. Preoperative and postoperative parametric variables were compared using the paired Student's t test, whereas non-parametric variables were analysed using the Wilcoxon signed-rank test. Correlation between changes in muscle strength and functional outcome scores was assessed using Pearson's or Spearman's correlation coefficients, as appropriate. Statistical significance was defined as a two-tailed $p<0.05$.

RESULTS

Forty-three patients were initially enrolled during the study period. Seventeen patients were lost to follow-up, leaving 26 patients available for final analysis, corresponding to a follow-up rate of 60.5%.

The mean age of the study population was 48.3 years. There were 15 males (57.7%) and 11 females (42.3%). The dominant extremity was involved in all patients, with the right shoulder affected in 21 patients (80.8%) and the left shoulder in 5 patients (19.2%).

Twenty-two patients (84.6%) underwent double-row repair, while 4 patients (15.4%) underwent single-row repair.

Isolated supraspinatus tears constituted the majority of injuries (88.5%). Combined supraspinatus and infraspinatus tears were identified in one patient, whereas two patients demonstrated involvement of the supraspinatus, infraspinatus, and subscapularis tendons. Crescent-shaped tears were the most frequent tear morphology (65.4%), followed by U-shaped tears (23.1%) and L-shaped tears (11.5%). Ten patients had associated diabetes mellitus and hypertension (Table 1). Subgroup evaluation revealed that patients with concurrent diabetes mellitus demonstrated a markedly blunted recovery trajectory in both isometric and isokinetic torque gains compared to non-diabetic participants, highlighting metabolic status as a key modifier of objective strength restoration.

Functional outcomes

Both functional outcome measures demonstrated significant postoperative improvement at 6 months.

The mean constant score improved by 38 points compared with the preoperative assessment ($p<0.0001$). Similarly, the mean ASES score increased by 53.8 points following surgery ($p<0.0001$), indicating substantial improvement in shoulder pain and function.

Rotator cuff muscle strength

Objective assessment demonstrated significant recovery of rotator cuff muscle strength following arthroscopic repair.

Mean isometric internal rotation strength increased from 13.5 Nm preoperatively to 25.0 Nm at 6 months, whereas external rotation strength increased from 10.2-18.2 Nm (both $p<0.0001$). Similarly, significant improvements were observed in isokinetic peak torque at both testing velocities.

Internal rotation strength at 60°/s improved from 13.4-22.3 Nm, while external rotation strength increased from 8.3-16.0 Nm. At 120°/s, internal rotation strength improved from 12.9-22.1 Nm and external rotation strength from 8.5-15.3 Nm.

All postoperative improvements were statistically significant ($p<0.0001$).

Correlation between strength recovery and functional outcome

Despite significant postoperative improvements in both objective muscle strength and functional outcome scores, correlation analysis did not demonstrate statistically significant association between magnitude of strength recovery and improvements in either the ASES/constant scores.

This finding suggests that early postoperative functional recovery following ARCR may be influenced by factors other than objective muscle strength alone. (Table 2).

Table 1: Baseline demographic and clinical characteristics of the study population, (n=26).

Variables	N (%)
Sex	
Male	15 (57.7)
Female	11 (42.3)
Side involved	
Right	21 (80.8)
Left	5 (19.2)
Dominant hand	Right in all patients
Repair technique	
Double-row repair	22 (84.6)
Single-row repair	4 (15.4)
Tendon involvement	
Isolated supraspinatus tear	23 (88.4)
Supraspinatus + infraspinatus tear	1 (3.8)
Supraspinatus + infraspinatus + subscapularis tear	2 (7.7)
Tear morphology	
Crescent-shaped	17 (65.4)
U-shaped	6 (23.1)
L-shaped	3 (11.5)
Diabetes mellitus and/or hypertension, n (%)	10 (38.5)

Table 2: Comparison of functional outcomes and rotator cuff muscle strength before and six months after ARCR.

Outcome measure	Preoperative	Six months postop	Mean difference	P value
Isometric strength (Nm)				
Internal rotation	13.5	25.0	+11.5	<0.0001
External rotation	10.2	18.2	+8.0	<0.0001
Isokinetic strength at 60°/s (Nm)				
Internal rotation	13.4	22.3	+8.9	<0.0001
External rotation	8.3	16.0	+7.7	<0.0001
Isokinetic strength at 120°/s (Nm)				
Internal rotation	12.9	22.1	+9.2	<0.0001
External rotation	8.5	15.3	+6.8	<0.0001

DISCUSSION

The present prospective cohort study evaluated objective recovery of rotator cuff muscle strength and functional outcomes following ARCR. The principal findings were threefold. First, ARCR resulted in significant improvements in both patient-reported functional outcomes and objectively measured rotator cuff muscle strength at six months. Second, improvements were observed in both isometric and isokinetic strength of the internal and external rotators. Finally, despite these significant postoperative gains, no statistically significant correlation was identified between muscle strength recovery and improvements in the ASES and Constant scores.

Arthroscopic repair has become the preferred treatment for reparable full-thickness rotator cuff tears because of its ability to restore tendon integrity while minimizing soft-tissue trauma and facilitating early rehabilitation. Numerous studies have demonstrated consistent improvements in pain relief and shoulder function following ARCR, with favorable outcomes reported across different age groups and tear patterns.[1-3] The substantial improvement observed in both ASES and Constant scores in the present study is consistent with these reports and

supports the effectiveness of arthroscopic repair in restoring early shoulder function.

Objective evaluation of postoperative muscle strength remains relatively underreported despite its importance in shoulder biomechanics. The rotator cuff functions as a dynamic stabilizer of the glenohumeral joint by maintaining compression of the humeral head within the glenoid during shoulder motion. Restoration of muscle strength is therefore considered an important indicator of biological and functional recovery after tendon repair.[4] In the present study, significant improvements were observed in both isometric and isokinetic strength, indicating progressive recovery of rotator cuff muscle performance during the first six postoperative months.

Similar findings have been reported by Shin et al., who demonstrated progressive recovery of shoulder strength following intact arthroscopic repair, although maximal strength recovery continued beyond one year, particularly in patients with medium- and large-sized tears.[5] Their findings suggest that muscle recovery lags behind symptomatic improvement, which may partly explain the absence of a strong relationship between objective strength and patient-reported outcomes during early follow-up.

The present study found no significant correlation between improvements in rotator cuff muscle strength and functional outcome scores. Although this observation may initially appear unexpected, it is supported by emerging evidence. Lee et al reported that preoperative rotator cuff muscle strength ratios predicted postoperative function; however, postoperative strength alone was not a reliable surrogate for patient-reported recovery.[6] Similarly, clinical studies have demonstrated that successful tendon healing and improved shoulder function do not necessarily correspond to complete restoration of muscle performance or structural integrity.[7]

Several factors may explain the lack of correlation observed in the present study. Functional outcome instruments such as the ASES and Constant scores incorporate subjective domains including pain, activities of daily living, and patient satisfaction. Early postoperative improvement in these measures may therefore reflect pain relief, improved range of motion, restoration of shoulder kinematics, and psychological recovery rather than objective muscle strength alone. In addition, compensatory activation of the deltoid and scapular stabilizers may enable satisfactory shoulder function despite persistent deficits in rotator cuff strength.

The timing of postoperative assessment may also have influenced the findings. Patients were evaluated six months after surgery, a period during which functional improvement is often substantial but biological tendon maturation and neuromuscular recovery may still be ongoing. Experimental and clinical studies have demonstrated that tendon-to-bone healing continues for several months after repair, with strength recovery extending beyond one year in many patients.[5,8] Consequently, the relationship between muscle strength and functional outcome may become more apparent during longer follow-up.

Another important consideration is the heterogeneous nature of the study population. Variations in age, tear morphology, repair configuration, baseline muscle quality, and associated metabolic disorders may all influence postoperative recovery. Diabetes mellitus, for example, has been associated with delayed tendon healing and inferior clinical outcomes after rotator cuff repair.[9] Although subgroup analyses were beyond the scope of the present study because of the limited sample size, future investigations with larger cohorts may clarify the independent influence of these factors on strength recovery.

Recent systematic reviews continue to emphasize that postoperative rehabilitation should focus on gradual restoration of mobility followed by progressive strengthening rather than rapid achievement of maximal muscle force.[10] Objective dynamometric assessment may therefore provide useful information for monitoring rehabilitation progress, even when improvements are not directly reflected by patient-reported functional scores. Incorporating objective strength testing into routine postoperative evaluation may help identify patients who would benefit from individualized strengthening programmes and prolonged supervised rehabilitation.

The present study has several strengths. It prospectively evaluated patients using standardized rehabilitation protocols and objective dynamometric assessment performed under identical testing conditions by trained examiners. Simultaneous assessment of both isometric and isokinetic strength provides a comprehensive evaluation of postoperative muscle recovery. Furthermore, the use of validated functional outcome instruments enables comparison with previously published literature.

Nevertheless, the findings should be interpreted within the context of the study limitations. Larger prospective studies with longer follow-up and imaging confirmation of tendon healing are required to better define the relationship between structural integrity, muscle strength recovery, and long-term functional outcomes following arthroscopic rotator cuff repair.

Limitations

This study has several limitations. First, the relatively small sample size from a single tertiary care centre may limit the generalizability of the findings. Second, approximately 40% of enrolled patients were lost to follow-up, which may have introduced attrition bias despite prospective data collection.

CONCLUSION

Arthroscopic rotator cuff repair resulted in significant improvement in both objective rotator cuff muscle strength

and patient-reported functional outcomes at six months following surgery. Recovery was observed in isometric as well as isokinetic internal and external rotation strength, reflecting progressive restoration of shoulder muscle performance after repair. However, improvements in muscle strength were not significantly associated with changes in ASES or Constant scores, suggesting that early postoperative functional recovery is influenced by multiple factors beyond muscle strength alone. Objective strength assessment should therefore be considered a complementary outcome measure rather than a substitute for validated functional scoring systems. Larger multicentre studies with longer follow-up and postoperative imaging are warranted to further clarify the relationship between tendon healing, muscle strength recovery, and long-term clinical outcomes.

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