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Postural balance impairment following arthroscopic rotator cuff repair in the early postoperative period: a prospective cohort study

İnci Hazal Ayas[1*], Seyit Çıtaker[1] and Ulunay Kanatlı[2]

Abstract

Background For patients undergoing arthroscopic rotator cuff repair surgery (RCR), it is crucial to prevent falls to minimize the risk of re-tearing the repaired muscles. Shoulder immobilization during the postoperative period may lead to a decline in postural balance. This prospective cohort study aimed to investigate the postural balance of patients in the early postoperative period following arthroscopic RCR.

Methods Thirty-five patients (17 female/18 male, aged 49.56 ± 13.41 years) were assessed preoperatively, on the postoperative day 2, and at the postoperative week 6. Postural balance was evaluated using the Overall Stability Index (OSI), Antero-Posterior Stability Index (API), Medio-Lateral Stability Index (MLI), and Limits of Stability (LOS) tests conducted with the Biodex Balance System. Additionally, the Visual Analog Scale (VAS) pain score and Constant-Murley Score were recorded.

Results The OSI and API values recorded on both postoperative day 2 and postoperative week 6 were statistically significantly worse than preoperative values. ($p = 0.02$, $p = 0.03$, respectively). Conversely, no statistically significant differences were observed across all three measurements for the MLI and LOS values ($p > 0.05$). The VAS score demonstrated a statistically significant decrease, while the Constant-Murley Score exhibited a statistically significant increase at the final measurement (both $p < 0.001$).

Conclusion This study highlights that postural stability significantly declines during the early postoperative period following arthroscopic rotator cuff repair, with specific impairments in anterior-posterior stability, despite improvements in pain and shoulder function. These findings underscore the need for early, targeted rehabilitation interventions to address balance deficits and reduce the risk of falls, potentially improving overall recovery outcomes.

Keywords Rotator Cuff injuries, Arthroscopy, Postural balance, Rehabilitation

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Introduction

Rotator cuff tears are a common cause of shoulder dysfunction and often necessitate surgical intervention to restore function and alleviate pain. Arthroscopic rotator cuff repair (RCR) is a less invasive alternative to open surgery, offering shorter postoperative recovery times and faster functional improvements [1, 2]. Despite these advantages, complications such as tendon rerupture remain a significant concern, particularly in cases involving large tears or patients with risk factors such as poor tissue quality or inadequate healing responses [3, 4]. Studies have reported a wide range of re-tear rates, spanning from 7 to 94% [4–7].

Avoiding falls during the postoperative period is crucial not only to prevent reruptures but also to reduce the risk of secondary injuries such as fractures. The incidence of falls following arthroscopic RCR is notably high, reaching 13.8% within the first five weeks, which is significantly higher than the incidence of falls following knee (3.6%) and hip (2.6%) arthroplasties [8]. This elevated fall risk has been attributed to impaired walking balance, often resulting from the shoulder abduction brace used during postoperative recovery. Similarly, shoulder immobilization following proximal humeral fractures has been shown to negatively affect balance [9]. These findings suggest that shoulder dysfunction and immobility may impair postural stability, as evidenced by the high incidence of falls in the early recovery period after RCR.

Postural balance, or postural control, refers to an individual's ability to maintain their center of gravity within their base of support, whether stationary or in motion [10]. Achieving and maintaining postural balance requires the integration of sensory inputs (visual, vestibular, and proprioceptive) and motor responses to stabilize the body against external perturbations [10]. Postural balance is essential for functional mobility, especially in patients recovering from musculoskeletal surgeries such as arthroscopic RCR. Shoulder immobilization, commonly prescribed postoperatively, may disrupt the body's natural balance mechanisms, thus increasing the risk of falls, particularly in the early postoperative period. Given that re-tear rates are significantly higher in patients who fall or fail to adhere to postoperative protocols, assessing and addressing postural stability is critical for optimizing rehabilitation outcomes and preventing complications.

According to the American Association of Shoulder and Elbow Therapists' consensus statement on rehabilitation after arthroscopic rotator cuff repair, the first phase of the rehabilitation program, Phase 1, spans the first six weeks postoperatively [3]. While this phase focuses on early recovery, such as pain control and passive range of motion exercises, the guide recommends starting postural stability exercises (e.g., dynamic stabilization, core exercises, and kinesthetic awareness exercises) only during Phase 3, which begins after the 12th week of recovery [3]. The second phase (weeks 6 to 12) typically focuses on gradually increasing active range of motion and introducing light strengthening exercises to enhance shoulder function [3]. However, this phase does not specifically target postural stability, which is delayed until later phases of rehabilitation. Given that shoulder dysfunction and gait-related impairments may arise early in the recovery period, and considering the potential contribution of shoulder immobilization to balance issues and fall risk, it is plausible that patients could experience balance difficulties as early as Phase 1 of the postoperative period. However, the impact of arthroscopic RCR on postural stability during this early phase remains unclear.

The aim of this study is to assess postural balance in patients during the early postoperative period following arthroscopic rotator cuff repair. We hypothesize that patients undergoing arthroscopic rotator cuff repair will exhibit compromised postural stability in the early postoperative period compared to their preoperative baseline.

Methods

The study received ethical approval from the Gazi University Ethical Committee on February 21, 2022, and informed consent was obtained from all participants. The study planned a prospective cohort study included patients who underwent arthroscopic rotator cuff repair surgery between March 2022 and March 2023 in the Orthopaedics and Traumatology Clinic of the Faculty of Medicine Hospital affiliated with the authors.

Participants

The inclusion criteria for patients were: (1) Patients aged between 18 and 65, (2) Patients who underwent unilateral arthroscopic rotator cuff repair surgery, and (3) Patients with tear size less than 5 cm. Exclusion criteria for patients were: (1) Patients with two or more tendon tears (massive tears), (2) Patients with any shoulder pathology other than rotator cuff tear, (3) Patients with any orthopedic or neurological pathology affecting balance or function, and (4) Patients with any previous shoulder surgery (Fig. 1). All patients were operated on by a single surgeon under interscalene block anesthesia using the double-row equivalent tension technique.

Procedure

Patients wore a neutral shoulder sling for 4 weeks after the surgery. Each patient underwent evaluation three times in total: before surgery (first), on the postoperative day 2 (second), and at the postoperative week 6 (third). All data were collected by a single expert physiotherapist to ensure consistency across evaluations. Preoperative assessments were conducted either on the day before surgery or on the day of surgery, depending on the patient's

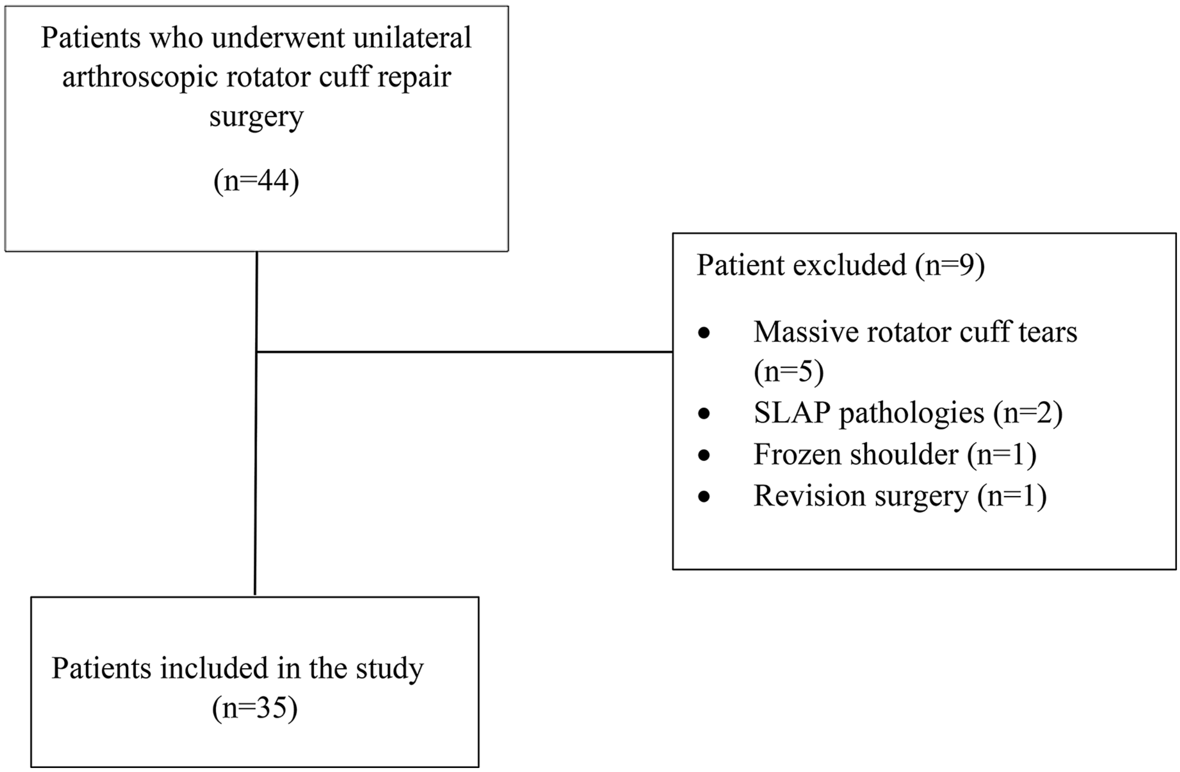

Fig. 1 Flowchart of the patient inclusion

schedule. In the second evaluation conducted on the postoperative day 2, all patients were using a neutral shoulder sling. Patients did not use a shoulder sling in the first and third evaluations. The same rehabilitation protocol, as detailed in the postoperative rehabilitation section, was administered uniformly to all patients following surgery.

Measurements

Pain intensity of the patients was assessed using the Visual Analogue Scale (VAS), while their shoulder functionality was evaluated using the Constant-Murley Score. The VAS, consists of a 10 cm line, with two endpoints representing 0 'no pain' and 10 'pain as bad as it could be' [11]. Pain intensity is expressed by marking a position along this line, ranging from 0 to 10 [11]. Postural balance was measured using the Biodex Balance System (Biodex Medical Systems; Biosway, Shirley, New York). Balance assessment involved the calculation of the stability indexes and Limits of Stability test (LOS). Overall Stability Index (OSI), Antero-Posterior Stability Index (API), Medio-Lateral Stability Index (MLI) indices were measured with eyes open during bilateral stance sway tests. A higher stability index value is indicative of poorer postural control [12]. During the LOS test, the patient stands on the platform and is instructed to shift their center of pressure (COP) within a specific target area displayed on a screen. LOS represents the greatest distance in which the COP can lean away from a midline vertical position without falling. A higher LOS value indicates better postural stability [13]. The measurement on postoperative day 2 was conducted while the patient was wearing a shoulder sling (Fig. 2). Furthermore, the Constant-Murley Score was utilized to assess shoulder function [14]. The score, which integrates both subjective patient-reported measures and objective physical findings, was used to evaluate functional outcomes. Pain is scored on a 15-point scale, activities of daily living are assessed through specific questions related to daily tasks, and range of motion is measured using a goniometer for flexion and abduction. External and internal rotation are evaluated by reaching specified anatomical landmarks, as outlined in the Constant Murley score instructions. Muscle strength is assessed by performing three maximal elevations against resistance using a handheld dynamometer in 90° abduction in the scapular plane, again measured and scored according to the instructions. The total score is calculated by summing the individual component scores, with a maximum of 100 points. Higher scores on the Constant-Murley Score signify superior shoulder function and reduced disability [14].

Postoperative rehabilitation

All patients followed a structured home-based rehabilitation program, based on the American Society of Shoulder and Elbow Therapists' consensus [3]. All patients

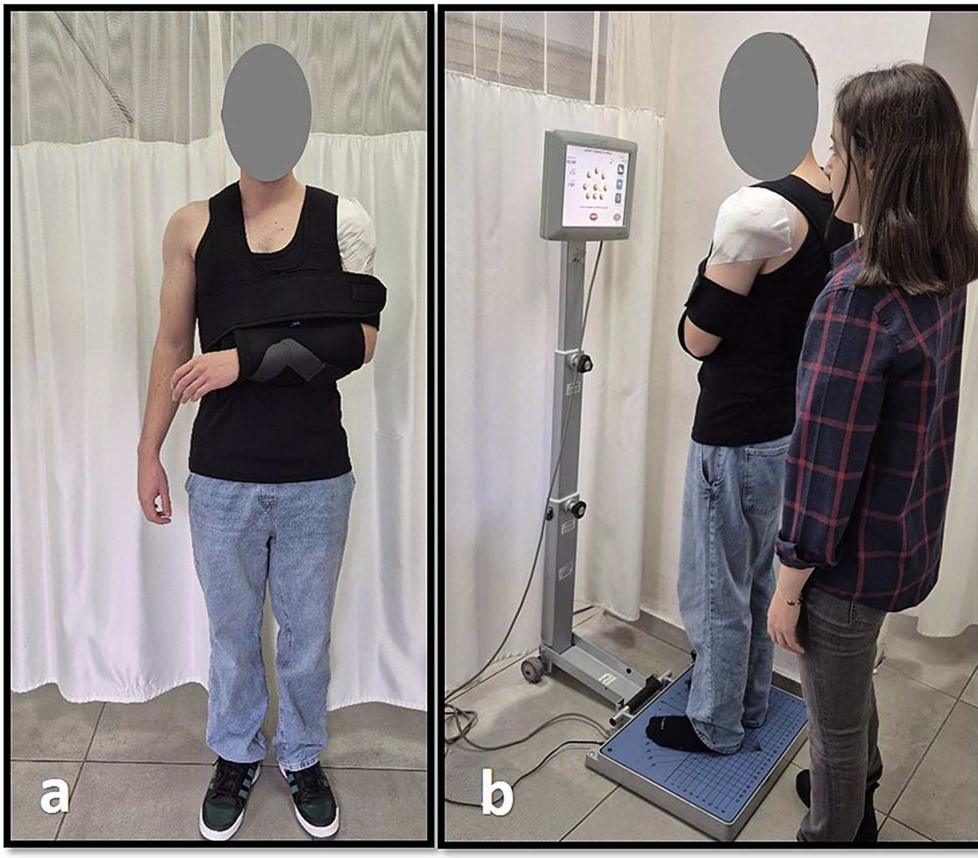

Fig. 2 **a**: Patient in Neutral Shoulder Sling, Postoperative Day 2, **b**: Balance Assessment Using Biodex Balance System, Postoperative Day 2

used a neutral shoulder sling for four weeks post-surgery. The exercises were performed three times daily, with 2 sets of 15 repetitions each. Weekly contact was made with all patients to ensure adherence, monitor progress, and reinforce compliance with the rehabilitation plan. No electrotherapy modalities were utilized in the postoperative period of this study. Patients underwent a final evaluation for the study at the sixth postoperative week (Phase 1); however, clinical follow-up for all patients continued thereafter. A detailed home-based exercise program for Phase 1 is provided in Table 1, and a summary of the postoperative rehabilitation protocol is outlined below.

Postoperative Rehabilitation Protocol:

Phase 1 (Postoperative Day 1 to Week 6): The primary goals during Phase 1 were to maintain the integrity of the surgical repair, minimize pain and inflammation, achieve range of motion (ROM) goals, and educate the patient on postoperative care. Pain management involved the use of cryotherapy. Active range of motion exercises (AROM) were introduced for the neck, elbow, and wrist. Pendulum exercises and early passive movement exercises for shoulder flexion, abduction, and internal and external rotation were initiated. Additionally, isometric shoulder strengthening exercises and grade I & II glenohumeral and scapulothoracic joint mobilizations were incorporated. The use of the shoulder sling was discontinued by the fourth week, at which point active-assisted ROM (AAROM) exercises for the shoulder began. To facilitate these exercises, patients performed wand exercises, pulley exercises, and forward rolling. Patients underwent a final evaluation for the study upon completion of the Phase 1 rehabilitation program.

Phase 2 (Postoperative Weeks 6 to 12): The objective during Phase 2 was to promote soft tissue healing, initiate active movement, and introduce light stretching exercises. Active-assisted ROM exercises for the shoulder continued, including pulley exercises, wand exercises and Swiss ball forward rolling. Periscapular exercises aimed at improving scapular stability were also introduced, with a focus on exercises such as the scapular clock. Progression from AAROM to AROM was encouraged, along with light stretching exercises for the shoulder. Light stretching exercises, with active assistance, were provided to target the anterior-posterior capsule, as well as shoulder flexion, abduction, and rotational range of motion.

Phase 3 (Postoperative Months 3 to 5): The goal of Phase 3 was to achieve full AROM, optimize neuromuscular control, and gradually restore shoulder strength.

Table 1 Detailed home-based exercise program for phase 1

Timeframe	Goals	Exercises / Interventions
Postoperative Day 1 – Week 2	- Educate the patient - Minimize pain and inflammation - Maintain repair integrity - Begin gentle movement	- Immobilization with neutral sling - During the first week, the patient will apply a cold pack to the surgical area for 15 min every 2–3 h while awake - Active flexion-extension, rotation, and lateral flexion exercises for the neck - Active flexion-extension exercises for the elbow - Active flexion-extension, supination-pronation, radial-ulnar deviation, finger abduction-adduction, and fist opening-closing exercises for the wrist and fingers. - Pendulum exercises with small circular movements - Passive shoulder flexion and abduction up to 90° - Passive internal and external shoulder rotation with the arm at the side, up to 30°
Week 2 – Week 4	- Achieve range of motion goals - Prevent stiffness	- Continue with the exercises listed above and immobilization with sling - Passive shoulder flexion and abduction up to 120° - Passive internal and external shoulder rotation up to 30° with the arm in 90° abduction - Grade I & II glenohumeral and scapulothoracic joint mobilizations - Submaximal isometric strengthening exercises in sling for shoulder flexion-extension-abduction-adduction
Week 4 – Week 6	- Begin active-assisted range of motion	- Discontinue sling use - Continue Grade I & II glenohumeral and scapulothoracic joint mobilizations - During all exercises, shoulder range of motion in all planes will be adjusted to stay within a pain minimal limit of 0–3 on the Visual Analog Scale - Shoulder flexion, abduction, internal and external rotation exercises using a wand - Pulley exercises - Ball forward rolling exercises - Forward bow exercises - Patient self-assisted supine forward elevation using the opposite hand - Scapular retraction, elevation, and depression exercises with arms at the sides

The rehabilitation program advanced with active shoulder exercises, stretching, and resistance training. Closed-chain exercises, as well as dynamic stabilization and proprioception exercises, were incorporated to enhance neuromuscular control and proprioception. Progressive resistance exercises targeting the rotator cuff, and periscapular muscles were introduced, using light weights and therabands. Closed-chain exercises were performed in quadruped and triped positions to further improve shoulder strength and stability. Light ball-catching and throwing exercises, along with light perturbation exercises, were initiated. Core strengthening exercises, as well as balance and coordination exercises on both hard and soft surfaces, were also included in the program, progressing from double-leg to single-leg stances.

Phase 4 (Postoperative Months 5 to 6+): The aim of Phase 4 was to achieve full strength and endurance to allow the patient to return to daily activities, work, or sports activities. Advanced strengthening exercises were focused on rotator cuff and periscapular muscles. Once patients achieved pain-free full range of motion, appropriate neuromuscular control, strength, and proprioception, they were permitted to resume full, unrestricted daily activities. A full return to unrestricted activities was allowed between the ninth and twelfth months.

Statistics

All statistical analyses were performed using IBM SPSS Statistics Version 23 software (IBM SPSS, Inc., Chicago, USA), and the data were expressed as mean ± standard deviation. The normality of the data was assessed using both visual methods (histograms and Q-Q plots), as well as analytical methods (Kolmogorov-Smirnov test). Parametric methods were used for measurement values suitable for normal distribution (Constant-Murley Score, Limits of Stability). In accordance with parametric methods, paired sample test (t-table value) is used to compare the measurement values of two dependent groups and repeated measures one-way ANOVA (F-table value) was used to compare the measurement values across the three time points. Bonferroni correction was applied for pairwise comparisons of the three measurements. Non-parametric methods were used for measurement values that did not comply with normal distribution (OSI, API, MLI, VAS). In accordance with non-parametric methods, the Friedman test ($\chi 2$-table value) method was used to compare the three measurements. Bonferroni correction was applied for pairwise comparisons.

A p-value lower than 0.05 was accepted as a significant difference. A sample size analysis using the G*Power 3.1 program determined that a minimum of 26 patients was required to achieve a power of 80%, with a 5% type I error [9]. The effect size (Cohen's f) for the analysis was calculated as 0.25, indicating a medium effect size.

Table 2 Basic characteristic of the patients

Variables	*n* = 35
Sex (Female / Male)	17 F / 18 M
Age (years)	49.56 ± 13.41
Height (meter)	1.67 ± 0.09
Weight (kilograms)	76.91 ± 12.85
BMI (kg/m^2)	27.59 ± 3.59
Dominance (Dominant / Nondominant)	15 D / 20 ND

Data for continuous variables presented as mean ± SD, and categorical variables presented as counts (n)

Table 3 Assessment of Pain, shoulder function, and postural balance across different time points

Variables	Preoperative	Postoperative day 2	Postoperative week 6	Statistics
VAS (0–10)	α 7.33 ± 2.44	α 7.62 ± 1.88	β 3.08 ± 2.11***	χ^2 = 28.339
CMS (0-100)	α 30.77 ± 14.95	-	β 46.45 ± 10.87***	t=-5.506
OSI	α 0.31 ± 0.10	β 0.41 ± 0.14	β 0.38 ± 0.12*	χ^2 = 7.398
API	α 0.25 ± 0.09	β 0.33 ± 0.14	β 0.30 ± 0.10*	χ^2 = 6.500
MLI	0.13 ± 0.07	0.15 ± 0.08	0.15 ± 0.09	χ^2 = 2.211
LOS	57.37 ± 10.76	59.56 ± 14.72	58.07 ± 17.21	F = 0.403

Data presented as mean ± SD

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

VAS: Visual Analogue Scale, CMS: Constant-Murley Score, OSI: Overall Stability Index, Antero-Posterior Stability Index (API), Medio-Lateral Stability Index (MLI), Limits of Stability test (LOS)

α: Values with the same letter are not significantly different from each other

β: Values with different letters are significantly different from those marked with a

Results

A total of 44 participant were initially assessed for eligibility. Of these, 9 were excluded based on the following criteria: 5 had massive rotator cuff tears, 2 had SLAP pathologies, 1 had frozen shoulder and 1 had revision surgery. Ultimately, 35 patients (17 female, 18 men, aged 49.56 ± 13.41 years) met the eligibility criteria were included in the study (Fig. 1). The basic characteristics of the patients are presented in Table 2. All participants in this study were sedentary individuals and did not engage in regular sports activities. Pain intensity revealed a statistically significant decrease in the VAS pain score during the third measurement compared to the first and second measurements ($p < 0.001$). Shoulder functionality was not evaluated during the second measurement (postoperative day 2) because patients were still immobilized in a shoulder sling, which would limit movement and provide unreliable results. Assessment of shoulder functionality using the Constant-Murley Score at the postoperative week 6 showed a statistically significant increase compared to the preoperative measurement ($p < 0.001$). The OSI and API values recorded at both the second and third measurements were significantly higher compared to the first measurement ($p = 0.02$, $p = 0.03$, respectively), indicating a decline in postural stability after surgery. No statistically significant differences were observed across all three measurements for the MLI and LOS values ($p > 0.05$), as shown in Table 3.

Discussion

The present study demonstrates a decline in postural stability among patients during the early period following arthroscopic rotator cuff repair surgery, with no observed improvement even by the sixth postoperative week. However, a significant reduction in pain and improvement in shoulder function compared to baseline were observed by the sixth postoperative week. Additionally, there was no alteration in LOS values during the early postoperative period. These findings support our hypothesis that patients undergoing arthroscopic rotator cuff repair surgery would exhibit compromised postural stability in the early postoperative period compared to their preoperative baseline. Despite improvements in pain and shoulder function, postural stability remained impaired, underscoring the need for targeted rehabilitation interventions to address balance deficits during this crucial recovery phase.

The use of a shoulder brace, which is commonly used postoperatively can lead to impaired gait performance, balance and increase the risk of falls [8, 9]. Notably, more than half of falls after elective shoulder arthroplasty occur during the first six weeks postoperatively, a period when patients typically use a shoulder sling [15]. A study on 38 healthy individuals demonstrated that shoulder joint immobilization led to decreased velocity, step length, and stride length, along with increased step width and single support time [16]. Based on these findings, the authors recommended the incorporation of gait and balance training for patients following shoulder immobilization [16]. We concur with this recommendation and propose that balance exercises be introduced while patients are still using a sling, as this may prevent gait abnormalities, reduce fall risk, and potentially avoid tendon re-rupture. In our study, the shoulder brace was discontinued after the fourth postoperative week, yet imbalance persisted in measurements taken during the sixth postoperative week. This finding indicates that balance deficits remain even after the removal of the shoulder immobilization brace.

To our knowledge, no studies have specifically evaluated postural balance in the acute period following rotator cuff repair. However, when examining similar literature, a study that provided balance training to individuals with chronic rotator cuff disease who were managed conservatively reported improvements in stability indexes after training [17]. Surprisingly, despite these improvements, the study found no significant enhancements in postural control or health-related quality of life. The authors concluded that adding a non-supervised home-based balance training protocol to the physical therapy program did not yield additional benefits in terms of postural control or quality of life in patients with rotator cuff disease [17]. However, this study had several limitations. For example, it did not compare the patients' pre-treatment balance to a healthy control group, leaving it unclear whether their baseline balance was impaired or within normal limits. Furthermore, the study only defined the patient population as individuals experiencing pain related to rotator cuff disease for at least four weeks, without specifying the type, severity, or duration of the tear, or whether the patients had undergone prior rehabilitation [17]. In contrast, our study suggests that incorporating balance training into the rehabilitation program may be necessary even in the early postoperative period following rotator cuff repair. This early intervention could potentially address the balance deficits observed during this critical phase of recovery. Additionally, a separate study examining core muscle endurance one year after rotator cuff repair found that patients exhibited reduced core muscle endurance compared to healthy controls [18]. Although this finding is not directly related to balance, it is plausible that diminished core muscle endurance may contribute to postural instability. The balance impairments observed in our study during the acute postoperative period could potentially persist or worsen in the chronic phase as core muscle endurance declines.

In our study, patients who used a sling postoperatively exhibited worse balance, raising questions about whether sling immobilization is necessary in all cases. A randomized prospective study investigating sling versus non-sling immobilization for minor to moderate tendon tears found that patients without a sling had better range of motion at the 6th and 12th postoperative weeks, with no significant differences in pain intensity compared to those who were immobilized [19]. The authors concluded that sling immobilization might not be necessary for minor or moderate tendon tears, as early mobilization seemed to enhance recovery outcomes [19]. These findings align with our observation of reduced balance in sling users, suggesting that early mobilization, without sling immobilization, could prevent such issues. Future studies should investigate whether avoiding sling use could improve postoperative outcomes, such as balance, mobility, and overall functional recovery, without increasing pain or the risk of re-injury. Improving the management of rehabilitation programs after arthroscopic rotator cuff repair remains a priority.

Although the underlying mechanism is not fully understood, it is well-established that painful and symptomatic shoulder pathologies negatively impact postural stability and balance [20, 21]. While we did not include a comparison with healthy controls in this study, we demonstrated that the static balance of patients with rotator cuff tears deteriorated after surgery. Postural balance testing using bilateral stance sway tests with eyes open provides valuable information about an individual's ability to utilize visual input for postural control. This test mimics real-life situations where visual feedback is available to maintain balance.

The Overall Stability Index represents the relative amount of motion within the available physiological ranges. It has been shown that 95% of the variance in OSI can be accounted for by the Anterior-Posterior Index, suggesting that OSI and API are nearly identical [12]. In contrast, the Medial-Lateral Index (MLI) accounts for a very small portion of the variance in OSI [12]. Our study revealed that OSI and APSI values, recorded both on postoperative day 2 and at the sixth postoperative week, showed significant deterioration compared to preoperative values. In contrast, no statistically significant differences in MLI were observed across all three measurements. The lack of significant change in MLI values compared to the deterioration in anterior-posterior stability may be attributed to several factors. First, anterior-posterior movements are more heavily involved in functional activities, such as walking or reaching, which could result in greater postural instability in the sagittal plane (forward-backward direction) [12]. In contrast, medial-lateral stability (side-to-side) may not be as directly impacted by shoulder dysfunction since activities involving lateral stability often rely more on lower limb control and core stability [12], which may remain relatively unaffected by the surgical procedure. Moreover, it is possible that compensatory mechanisms, such as adjustments in trunk and lower limb movements, helped maintain stability in the lateral direction, preventing significant changes in MLI. Additionally, the reliability of MLI has been reported to be lower compared to anterior-posterior measures, with poor intertester and intratester ICCs [22]. This could suggest that MLI is a less sensitive measure for detecting postural instability, which could explain why no significant differences were observed.

The Limits of Stability (LOS) test is a clinical assessment used to measure an individual's ability to control their center of gravity within the limits of their base of support in various directions [10]. Unlike static balance tests that assess balance in a stationary position, the LOS test evaluates the individual's ability to control their balance while moving within their base of support, providing valuable information about dynamic postural control [10]. This dynamic stability is essential for daily activities, sports performance, and fall prevention. In our study, despite a decline in postural stability, patients' limits of stability remained preserved. The OSI and APSI primarily assess postural stability during bilateral stance sway tests, which evaluate the ability to maintain balance in a static position. In contrast, the LOS test offers a more comprehensive assessment of an individual's ability to integrate multiple sensory inputs related to balance and compensate when one or more of these senses is impaired [23]. The LOS test assesses the maximal distance a person can lean in different directions without losing balance, providing insight into dynamic stability and the ability to control body movements over a larger range of motion. While patients may experience difficulties in maintaining balance in a static stance, such as during bilateral stance sway tests, their ability to control body movements within a larger range of motion may remain relatively unaffected. This could be due to compensatory mechanisms or motor control strategies that allow individuals to compensate for deficits in static postural stability by relying on dynamic stabilization mechanisms.

The risk of re-tear in patients experiencing compliance issues with the use of slings and rehabilitation programs in the postoperative period, along with any accidents or falls, is 152 times higher within the first 6 weeks compared to compliant patients [24]. Therefore, it is crucial to protect individuals from falls during the early postoperative period. According to rehabilitation guidelines provided by the American Association of Shoulder and Elbow Therapists for rehabilitation following arthroscopic rotator cuff repair, exercises aimed at enhancing postural stability, such as dynamic stabilization exercises, core exercises, and kinesthetic awareness exercises, are typically initiated after the 12th postoperative week [3]. Similarly, a review that generated an evidence-based guide for rehabilitation after arthroscopic rotator cuff repair recommended exercises that improve static stability, such as closed-chain stability exercises, rhythmic stabilization, and weight shifts, after the second postoperative month [25]. Current rehabilitation guidelines suggest that postural stability exercises are initiated in the mid to late postoperative period. However, delaying the implementation of stability-focused exercises may pose challenges in addressing postural stability deficits early in the recovery process. Evidence from our study suggests that incorporating stability exercises earlier in the rehabilitation process, particularly those targeting static stability, may offer significant benefits. Future research should explore the efficacy of early initiation of stability-focused exercises and the potential impact of preoperative protocols, such as lower limb training, on improving postural stability and reducing the risk of falls following arthroscopic rotator cuff repair surgery. Experimental studies comparing early versus late rehabilitation outcomes could provide valuable insights into optimizing postoperative recovery.

Our findings revealed a decline in postural stability following arthroscopic rotator cuff repair, but this decline was not uniform across all stability measures. Specifically, significant deterioration was observed in the OSI and the API, both of which primarily assess stability in the sagittal plane. In contrast, no significant changes were observed in MLI, which evaluates lateral stability in the frontal plane, or in the LOS test, which assesses dynamic postural control. These results suggest that certain aspects of postural stability, particularly those involving forward-backward movements, are more affected by rotator cuff repair than others. The lack of change in MLI and LOS could indicate the presence of compensatory mechanisms in lateral stability and dynamic balance, or it may suggest that these aspects of stability are less dependent on shoulder function. This distinction is important for interpreting the clinical implications of our findings, as it highlights the need for targeted rehabilitation approaches that improve anterior-posterior stability while maintaining lateral and dynamic stability.

Limitations

The current study has several limitations that should be acknowledged. First, the inclusion criteria restricted participation to patients with tear sizes less than 5 cm, which may limit the generalizability of our findings to individuals with larger rotator cuff tears. Additionally, the broad age range of the participants may have introduced variability in the results, particularly regarding the impact of age on postoperative recovery. While we adhered to a general rehabilitation protocol based on consensus guidelines, minor variations in patient adherence to home-based exercises could have influenced individual recovery outcomes. Another limitation is the relatively short follow-up period, which may not fully capture long-term trends in postural stability and overall recovery. A longer follow-up period could provide further insights into the progression of balance impairments beyond the early postoperative phase. Moreover, although the Limits of Stability test assesses aspects of dynamic stability, our primary assessment of postural stability relied on the Biodex Balance System, which focuses primarily on controlled movements. While more comprehensive functional mobility tests were not included, the chosen methods were suitable for evaluating balance impairments in the early postoperative period, particularly given the safety considerations during recovery from rotator cuff repair surgery.

Conclusions

In conclusion, our study demonstrates that patients experience a significant decline in postural stability during the early postoperative period following arthroscopic rotator cuff repair surgery, particularly in overall and anterior-posterior stability. Despite improvements in pain intensity and shoulder function, these balance impairments persisted without notable improvement by the sixth postoperative week. These findings underscore the importance of addressing postural stability early in the rehabilitation process to reduce fall risks and enhance overall recovery outcomes.

Current rehabilitation guidelines typically recommend stability-focused exercises later in the postoperative period; however, our results suggest that earlier incorporation of these exercises may be beneficial. Targeted interventions to improve balance, particularly in the anterior-posterior plane, should be considered in early rehabilitation protocols to optimize functional recovery and minimize complications. Future research is needed to explore the efficacy of early balance training and its impact on long-term postoperative outcomes.

Abbreviations

RCR	Rotator cuff repair
OSI	Overall Stability Index
API	Antero-Posterior Stability Index
MLI	Medio-Lateral Stability Index
LOS	Limits of Stability
COP	Center of pressure
VAS	Visual Analog Scale

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Author contributions

Conceptualization, A.İ.H; Methodology, A.İ.H, Ç.S.; Investigation, A.İ.H, Ç.S.; Formal Analysis, A.İ.H; Writing - Original Draft, A.İ.H; Writing - Review & Editing, A.İ.H., Ç.S., K.U. Supervision, Ç.S., K.U; Project Administration, A.İ.H, K.U. All authors reviewed the manuscript.

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Data availability

The datasets analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study received ethical approval from the Gazi University Ethical Committee on February 21, 2022, and informed consent was obtained from all participants.

Consent for publication

The authors confirm that written consent has been obtained from the patient shown in Fig. 2.

Competing interests

The authors declare no competing interests.

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