

Clinical and Radiological Outcomes of Rotator Cuff Repair With Versus Without Biceps Tenotomy: A 3D Volumetric Analysis of the Subacromial Space

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ABSTRACT

This study aims to compare the clinical and radiological outcomes of arthroscopic rotator cuff repair (RCR) performed with versus without concomitant long head of the biceps tendon (LHBT) tenotomy, including a three-dimensional (3D) volumetric analysis of the subacromial space.

This retrospective study included 43 patients who underwent unilateral arthroscopic single-row repair for small to medium supraspinatus tears between May 2021 and July 2023. Group I (n = 24) underwent RCR with LHBT tenotomy, while Group II (n = 19) underwent RCR alone. Clinical outcomes were assessed using the Visual Analog Scale (VAS) and the American Shoulder and Elbow Surgeons (ASES) score. Subacromial volume was evaluated using 3D MRI volumetric measurements obtained pre- and postoperatively.

In Group I, the mean VAS score decreased from 6.17 to 1.58 and the ASES score increased from 38.21 to 81.13 postoperatively. In Group II, the VAS score decreased from 5.95 to 1.37 and the ASES score increased from 42.32 to 82.47. Both groups showed significant postoperative improvements, but no intergroup difference was observed. Subacromial volume increased from 3.79 cm³ to 4.94 cm³ in Group I, and from 3.85 cm³ to 4.90 cm³ in Group II. Although both groups exhibited a significant postoperative increase in subacromial volume, no intergroup difference was observed in postoperative measurements.

In this cohort, no statistically significant additional benefit of concomitant LHBT tenotomy was demonstrated in terms of pain relief, functional improvement, or 3D subacromial volume restoration compared with rotator cuff repair alone.

Keywords: ASES score, biceps tenotomy, rotator cuff repair, subacromial volume, three dimensional measurement

Introduction

The rotator cuff is essential for maintaining shoulder stability and enabling overhead motion. Injury to this structure often results in shoulder pain, limited joint mobility, difficulty performing daily activities, and a decline in overall quality of life. Concomitant pathology of the long head of the biceps tendon (LHBT) has been reported in 36%–83% of patients presenting with rotator cuff tears. Previous research has also demonstrated that lesions of the LHBT serve as a key source of pain within the shoulder complex (1, 2). Although arthroscopic rotator cuff repair (RCR) is widely recognized as the preferred treatment option (3), the potential benefits of LHBT tenotomy remain a topic of ongoing debate (4-6).

Furthermore, the subacromial space represents an essential element in shoulder biomechanics, as it accommodates and protects crucial anatomical

structures, including the supraspinatus tendon and the subacromial bursa (7). Previous studies have suggested that a reduction in the subacromial space could play a role in the development of rotator cuff tendinopathy through mechanical impingement mechanisms. If impingement is not adequately resolved, this process may eventually progress to a full-thickness rotator cuff tear (8, 9). However, conventional two-dimensional imaging techniques may not fully reflect the complexity of subacromial space dynamics. Advancements in three-dimensional (3D) imaging have facilitated volumetric assessments, thereby enabling more precise evaluation of postoperative structural adaptations and their correlation with clinical recovery (10, 11).

The impact of concomitant LHBT tenotomy during RCR on the subacromial space has been addressed in only a limited number of studies. Several authors have proposed that the LHBT

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assists in glenohumeral stability by exerting a downward force on the humeral head, thereby limiting its upward displacement. (12). They have reported in their studies that concomitant biceps tenotomy may affect shoulder functions by narrowing the subacromial space (13). Conversely, studies have been conducted that suggest biceps tenotomy exerts minimal influence on the subacromial space and does not impact clinical outcomes (14). The influence of LHBT subacromial volume and its potential role in determining long-term clinical results after rotator cuff repair remains to be clarified.

This study was designed to evaluate and contrast postoperative functional and imaging-based parameters through 3D volumetric assessment among patients who received arthroscopic rotator cuff repair, either alone or combined with biceps tenotomy.

Materials and Methods

A retrospective analysis was conducted on data from 52 patients who underwent arthroscopic surgery for unilateral full-thickness rotator cuff tears at our institution between May 2021 and July 2023. The study population included individuals with isolated small- to medium-sized supraspinatus tendon tears treated using a single-row arthroscopic repair technique. Patients presenting with tears involving other rotator cuff muscles (such as the subscapularis or infraspinatus) (2 patients), massive cuff defects (2 patients), a prior ipsilateral shoulder fracture or surgery (1 patient), concomitant subacromial acromioplasty (3 patients), labral repair (1 patient), glenohumeral arthrosis, or adhesive capsulitis were excluded from the analysis. Participants who received arthroscopic rotator cuff repair combined with LHBT were assigned to Group 1, whereas those treated with rotator cuff repair alone were classified as Group 2. All study procedures adhered to the ethical standards outlined in the Declaration of Helsinki and were approved by the Sanko University Institutional Review Board (approval code: 202010-04).

Surgical Procedure and Post-Operative Care: All surgical procedures were carried out arthroscopically with patients positioned in the beach-chair configuration under general anesthesia. A single experienced shoulder surgeon performed all operations. Standard anterior, posterior, and lateral portals were established to access the glenohumeral joint and subacromial space. The initial step consisted of performing

glenohumeral arthroscopy, a procedure that facilitated the examination of both the LHBT and labral structures (Figure 1-a). The decision to intervene in LHBT was made by the same surgeon, according to intraoperative arthroscopic examination findings. In the event of a LHBT pathology being observed as degenerative changes, tendinitis (figure 1-b), or instability of the LHBT, arthroscopic tenotomy was performed (figure 1-c, 1-d). In patients with intact LHBT, no intervention other than rotator cuff repair was performed. Subsequent to the initial glenohumeral arthroscopy, subacromial arthroscopy was performed.

After completing the subacromial bursectomy, the extent of the supraspinatus tear was assessed using an arthroscopic probe. The torn supraspinatus tendon stump was then anatomically repositioned within its native footprint (figure 2-a), and fixation was achieved through a single-row repair technique employing push-lock anchors (figure 2-b). Post-surgically, a Velpeau bandage was applied to all patients. The patients were hospitalised for one night following surgery and discharged the following day. Following the surgical intervention, passive shoulder exercises and pendulum exercises were initiated on the same day. Postoperative evaluations were conducted at 3 and 6 weeks, and subsequently at 3, 6, and 12 months after surgery. After six weeks of immobilization with the Velpeau bandage, it was discontinued, and a structured physiotherapy program was commenced.

Outcome Assessment: Patients with a minimum of 12 months of postoperative follow-up were evaluated for preoperative and postoperative parameters. The Visual Analog Scale (VAS) was utilised to evaluate pain, while the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score was employed to assess functional outcomes. For the purpose of radiological evaluation, 3-D subacromial volume measurements obtained from the patients' preoperative and last follow-up MR images were utilised.

All MRI examinations were performed using a 1.5-T scanner. Coronal, sagittal, and axial T2-weighted sequences were obtained with a slice thickness of 4 mm and no interslice gap. The subacromial volume was determined through Volume Viewer software (v10.5.42; GE Healthcare, Canada, USA). All volumetric measurements were performed by an experienced musculoskeletal radiologist specializing in shoulder imaging, who was blinded to group allocation and clinical outcomes.

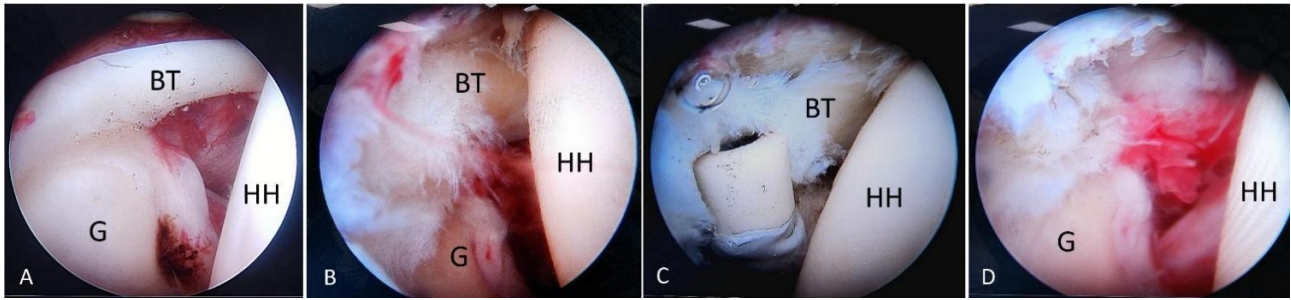


Fig. 1. Glenohumeral arthroscopy and evaluation of the LHBt

- a) The LHBt of a patient in group II, shown here, was intact and tenotomy has not been performed.
- b) The presence of biceps tendinopathy was observed in a patient in group I.
- c) The procedure of biceps tenotomy with radio frequency (RF) ablation probe.
- d) The glenohumeral joint following biceps tenotomy.

Abbreviations: G: Glenoid, BT: Biceps tendon, HH: Humeral head

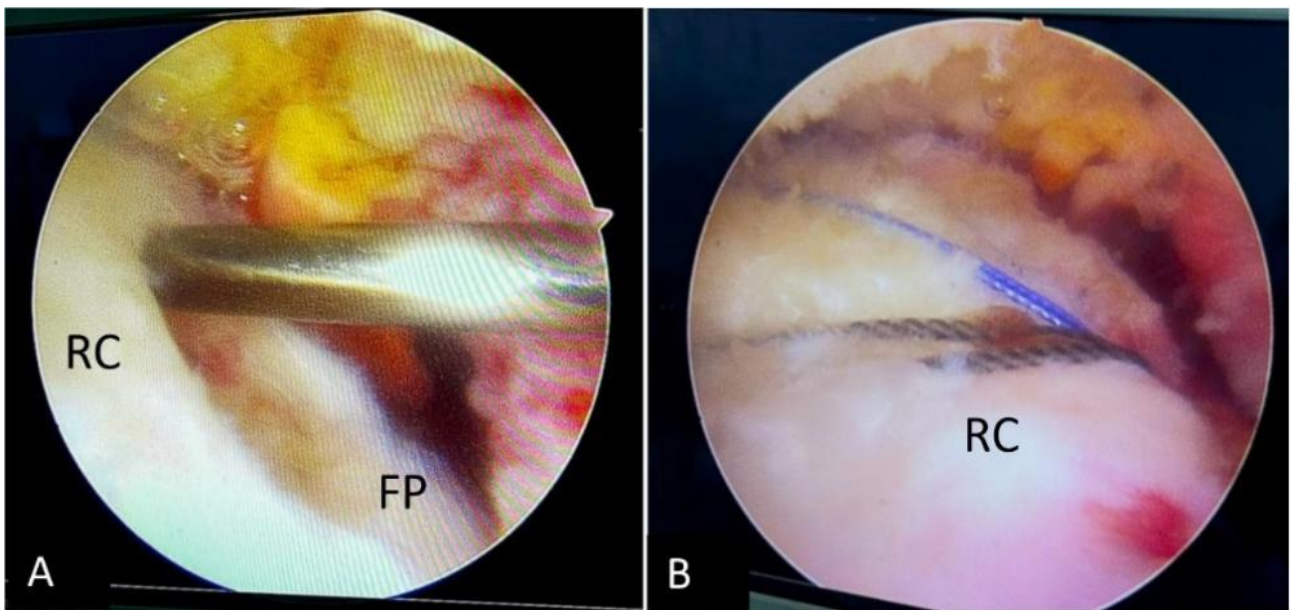


Fig. 2. Subacromial arthroscopy and evaluation of the Rotator cuff

- a) A full-thickness rotator cuff tear before repair.
- b) Following rotator cuff repair; single row repair

Abbreviations: RC: Rotator cuff, FP: Foot Print



Fig. 3. The 3D volumetric measurement of the subacromial space was conducted on three consecutive images (a, b and c) from sagittal sections from lateral to medial direction. The edges of the subacromial space were delineated with a pencil tool using the freehand method. Subsequently, (d) the volume in cubic centimetres was automatically calculated by the program

Measurements were obtained from sagittal T2-weighted sections. The analyzed region extended

from the lateral margin of the acromion to the acromioclavicular joint, encompassing the inferior

acromial surface and the articular surface of the humeral head, which were manually delineated using the freehand tool (figure 3-a,b,c). Subsequent to the completion of the selection process, the software automatically calculated the volume in cubic centimetres (Figure 3-d).

Statistical Analysis: All statistical analyses were carried out using SPSS software (version 25.0; IBM Corp. Armonk, NY, USA). The normality of continuous variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Variables with a normal distribution were expressed as mean \pm standard deviation, whereas non-normally distributed variables were presented as median and range. Within-group comparisons were performed using the paired t-test for normally distributed variables and the Wilcoxon signed-rank test for variables that did not meet the assumption of normality. Between-group comparisons were conducted using the independent samples t-test for normally distributed variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables, including sex and operated side, were compared using the chi-square test.

Associations between subacromial space volume and clinical outcomes (VAS and ASES scores) were evaluated using Spearman's correlation analysis. Correlation coefficients and corresponding p-values were calculated to determine the strength of these relationships.

The adequacy of the sample size was evaluated by post hoc power analysis using G*Power software (version 3.1). Based on the observed preoperative–postoperative change in VAS scores, with an alpha level of 0.05 and a total sample size of 43 patients, the statistical power of the study was calculated to be greater than 0.99. A p-value $<$ 0.05 was considered statistically significant.

Results

A total of 43 eligible patients meeting the inclusion criteria were included in the analysis. Participants were divided into two groups: Group I, consisting of patients who underwent biceps tenotomy ($n = 24$), and Group II, comprising those without biceps tenotomy ($n = 19$). The demographic characteristics—including age, sex distribution, laterality of the operated shoulder, and follow-up duration—were comparable between the groups (Table 1). The mean follow-up period was 22.17 ± 5.94 months in the biceps

tenotomy group and 21.11 ± 6.66 months in the non-tenotomy group, with statistical analysis revealing no significant difference ($p = 0.590$) (Table 1).

In Group I, the mean preoperative VAS score was 6.17 ± 1.31 , which significantly decreased to 1.58 ± 1.50 postoperatively ($p = 0.001$), indicating a marked reduction in pain following surgery (Table 2). Similarly, a marked reduction in pain was observed in Group II, as the mean VAS scores decreased from 5.95 ± 1.13 preoperatively to 1.37 ± 1.26 postoperatively ($p = 0.001$) (Table 2). When comparing preoperative VAS values across the two groups, no statistically significant difference was identified ($p = 0.559$) (Table 3). Postoperative VAS scores also did not differ significantly ($p = 0.612$), suggesting that both surgical approaches provided similar pain relief outcomes (Table 3). These findings imply that the addition of biceps tenotomy did not provide a superior analgesic benefit in the early postoperative period.

In terms of shoulder function, Group I demonstrated a significant improvement in the mean ASES score from 38.21 ± 9.9 preoperatively to 81.13 ± 12.2 postoperatively ($p = 0.001$) (Table 2). Likewise, Group II exhibited a significant rise in ASES scores, increasing from 42.32 ± 10.59 to 82.47 ± 11.93 after surgery ($p = 0.001$) (Table 2). Comparative analysis revealed no statistically significant difference in either preoperative ($p = 0.202$) or postoperative ($p = 0.718$) ASES values between the groups, suggesting that both interventions achieved similar levels of functional recovery (Table 3). These findings suggest that the absence of biceps tenotomy did not compromise functional outcomes following isolated rotator cuff repair.

Radiologic evaluation demonstrated that in Group I, the mean subacromial volume increased significantly from 3.79 ± 0.44 cm³ preoperatively to 4.94 ± 0.49 cm³ following surgery ($p = 0.001$) (Table 2). Similarly, Group II exhibited a significant postoperative increase, with mean values rising from 3.85 ± 0.41 cm³ to 4.90 ± 0.55 cm³ ($p = 0.001$) (Table 2). Comparison between the two groups revealed no statistically significant difference in either preoperative ($p = 0.679$) or postoperative ($p = 0.792$) subacromial volumes, suggesting comparable volumetric recovery patterns after repair (Table 3). These imaging results suggest that the addition of biceps tenotomy did not exert a measurable effect on subacromial decompression achieved through rotator cuff repair.

Table 1: Demographic Characteristics of The Groups

Variable	Group I / With Biceps Tenotomy n=24	Group II / Without Biceps Tenotomy n=19	P
Sex: M (%) /F (%)	10 (41.7 %) / 14 (58.3 %)	7 (36.8 %) / 12 (63.2 %)	0.994 *
Age (Years)			0.189 **
Mean ± SD (Range)	49.29 ± 10.42 (27-72)	45.37 ± 8.81 (29-63)	
Operated Side			
Right: n (%)	11 (45.8 %)	8 (42.1 %)	1.0 *
Left: n (%)	13 (54.2 %)	11 (57.9 %)	
Follow-up time (Months)			
Mean ± SD (Range)	22.17 ± 5.94 (12-35)	21.11 ± 6.66 (12-33)	0.590 **

Abbreviations: M: Male, F: Female, SD: Standard Deviation

Statistical tests: * Chi-square test ** Independent samples t-test

Table 2: Comparison of Preoperative and Postoperative Findings Within Group

Variable	Group	Pre-operative value	Post-operative value	P
VAS				
Mean ± SD	With Biceps Tenotomy	6.17 ± 1.31 6 (4-9)	1.58 ± 1.5 1 (0-6)	0.001 *
Median (Range)	Without Biceps Tenotomy	5.95 ± 1.13 6 (5-9)	1.37 ± 1.26 1 (0-5)	0.001 *
ASES score				
Mean ± SD	With Biceps Tenotomy	38.21 ± 9.9 38 (18-62)	81.13 ± 12.2 83.50 (44-100)	0.001 *
Median (Range)				

ASES: American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form

Statistical tests: * Paired-samples t test

Spearman correlation analysis was performed to evaluate the relationship between postoperative subacromial volume and clinical outcome measures. No significant correlation was found between postoperative subacromial volume and VAS scores ($r = -0.118$, $p = 0.451$). Similarly, no significant association was observed between postoperative subacromial volume and ASES scores ($r = 0.211$, $p = 0.174$).

Discussion

The current investigation revealed marked postoperative improvements in both pain intensity and functional performance among patients who underwent rotator cuff repair, with or without concurrent biceps tenotomy (Group I and Group II, respectively). Nonetheless, the comparison between the two cohorts indicated no statistically meaningful variation in postoperative VAS or

ASES scores. Likewise, although each group showed a significant postoperative enlargement of the 3D subacromial space relative to its preoperative measurement, the postoperative subacromial volumes were statistically comparable between the groups.

Multiple investigations have repeatedly shown that arthroscopic treatment of rotator cuff tears leads to a reduction in pain and substantial enhancement of shoulder function (15). Despite extensive research, the influence of concomitant biceps procedures for LHBT disorders on clinical outcomes continues to be debated. Moreover, the coexistence of rotator cuff tears with LHBT abnormalities has been thoroughly described across previous studies, with the prevalence reported to vary between 36% and 83% depending on the study population (13, 16). In line with these reports, our study demonstrated that 56% of patients (24 out of 43) exhibited LHBT pathology,

Table 3: Comparison of Clinical and Radiological Outcomes Between the Groups

Variable	Group I / With Biceps Tenotomy n=24	Group II / Without Biceps Tenotomy n=19	P
Pre-operative VAS			
Mean \pm SD	6.17 \pm 1.31	5.95 \pm 1.13	0.559 *
Median (Range)	6 (4-9)	6 (5-9)	
Post-operative VAS			
Mean \pm SD	1.58 \pm 1.5	1.37 \pm 1.26	0.612 *
Median (Range)	1 (0-6)	1 (0-5)	
Pre-operative ASES score			
Mean \pm SD	38.21 \pm 9.9	42.32 \pm 10.59	0.202 *
Median (Range)	38 (18-62)	40 (24-66)	
Post-operative ASES score			
Mean \pm SD	81.13 \pm 12.2	82.47 \pm 11.93	0.718 *
Median (Range)	83.5 (44-100)	86 (52-100)	
Pre-op subacromial volume (cm ³)			
Mean \pm SD	3.79 \pm 0.44	3.85 \pm 0.41	0.679 *
Range	2.81-4.62	2.98-4.53	
Post-op subacromial volume (cm ³)			
Mean \pm SD	4.94 \pm 0.49	4.9 \pm 0.55	0.792 *
Range	3.63-5.86	3.51-5.74	

Abbreviations: VAS: Visual Analogue Scale, SD: Standard Deviation

ASES: American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form

Statistical tests: *Independent samples t-test

indicating that our rate of concomitant LHBT pathology was consistent with the existing literature. Recent systematic reviews, such as that by Vigié et al., have highlighted the absence of a consensus, reporting that concomitant biceps procedures have not consistently been associated with superior functional outcomes compared to preservation of the LHBT (17). Watson et al. examined a cohort of 80 individuals who underwent rotator cuff repair and found that those who also received concomitant biceps procedures achieved significantly better functional outcomes compared with patients treated with cuff repair alone (18). Conversely, Nemirov et al. evaluated 244 patients, comparing 143 individuals who underwent isolated rotator cuff repair with 101 who had an additional biceps procedure. Their analysis revealed no statistically meaningful distinctions between the two cohorts regarding postoperative ASES scores, patient satisfaction, revision rates, or the incidence of complications (19). The outcomes of the current research align with the observations reported by Nemirov et al.,

as no statistically significant variations in clinical results were identified between patients undergoing rotator cuff repair alone and those receiving additional biceps tenotomy. Although the long head of the biceps tendon (LHBT) has been widely implicated as a notable contributor to anterior shoulder discomfort, the considerable restoration of shoulder biomechanics achieved following rotator cuff repair alone may compensate for other major sources of pain and dysfunction (20). Furthermore, while concomitant biceps surgery theoretically eliminates a pain generator, it may negatively influence shoulder and elbow biomechanics, potentially leading to muscle cramps and weakness, potentially prolonging the rehabilitation process and negatively impacting functional recovery (21). Thus, while concomitant biceps surgery may eliminate a potential pain generator, it might not yield clinically superior outcomes due to its biomechanical implications. Therefore, the net clinical effect of concomitant biceps surgery appears to be neutral when compared to rotator

cuff repair alone. Subsequent research should focus on determining which patient populations are most likely to derive significant benefit from the addition of concomitant biceps procedures. Stratifying patients based on the severity of LHBT pathology, preoperative functional status, and biomechanical considerations may help optimize surgical decision-making and improve individualized treatment outcomes.

In addition to clinical outcomes, structural restoration, subacromial space remodeling, plays a critical role in postoperative shoulder recovery. While it is well documented that arthroscopic rotator cuff repair increases subacromial space volume (12, 22), the specific impact of concomitant biceps procedures on this expansion remains controversial and underexplored. Çakar et al. have specifically examined this issue and reported that concomitant biceps tenotomy during RCR does not adversely affect the subacromial space (6). However, their evaluation was based on two-dimensional (2D) measurements, such as acromiohumeral distance, which may not fully capture the complex 3D remodeling of the subacromial region (23). Recent advances have emphasized the superiority of 3D volumetric analyses in providing a more comprehensive evaluation of postoperative structural adaptations (24, 25). Despite previous efforts, studies utilizing 3D MRI-based volumetric assessments are still scarce, and, as far as we are aware, none have directly examined the influence of concomitant biceps procedures on postoperative alterations in 3D subacromial volume following rotator cuff repair.

The present investigation adds new insight to the existing body of literature by employing 3D MRI volumetric analysis to explore subacromial space dynamics among patients treated with rotator cuff repair either alone or in combination with biceps tenotomy. Three-dimensional volumetric assessment demonstrated a significant postoperative increase in subacromial volume in both cohorts; however, no statistically significant difference was detected between repairs performed with or without concomitant biceps tenotomy. In addition, correlation analysis did not demonstrate a significant relationship between postoperative subacromial volume and clinical outcome measures. This finding suggests that improvements in pain and shoulder function following rotator cuff repair may not be directly associated with volumetric changes in the subacromial space. Instead, factors such as tendon healing, restoration of rotator cuff biomechanics,

and postoperative rehabilitation may play a more dominant role in determining clinical outcomes. From a clinical perspective, these findings indicate that postoperative enlargement of the subacromial space alone may not be a reliable predictor of functional recovery. Therefore, surgical decision-making should primarily focus on achieving an optimal rotator cuff repair rather than attempting to modify subacromial volume. By clarifying the effect of concomitant biceps intervention on three-dimensional subacromial volume alterations, the present study provides further insight into the structural and clinical implications of rotator cuff repair.

Individuals who received arthroscopic rotator cuff repair, either alone or in combination with a biceps tenotomy, exhibited marked postoperative improvements in both clinical and radiologic measures relative to their preoperative status. However, statistically notable differences were not observed between patients with or without biceps tenotomy, including volumetric 3D analysis of the subacromial space. The present study's notable strengths lie in its application of objective three-dimensional volumetric assessment and the consistency of a standardized surgical approach performed by a single experienced surgeon, thereby reducing procedural variability. Nonetheless, this work is not without limitations, such as its retrospective nature, modest sample size, and relatively brief follow-up period. Another limitation of this study is that the decision to perform LHBT tenotomy was based on intraoperative findings. Although baseline demographic and clinical parameters were comparable between the groups, differences related to the underlying LHBT pathology cannot be completely excluded. Further longitudinal investigations with expanded patient populations and longer observation intervals are warranted to more clearly define the long-term biomechanical and clinical implications of performing biceps tenotomy during rotator cuff repair.

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- tüm kaynaklar derginin yazım kuralına göre revize edilmelidir.