

# Effectiveness of Exercises With Electromyographic Biofeedback in Conservative Treatment of Massive Rotator Cuff Tears

## A Randomized Controlled Study

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**Objective:** The aim of the study is to investigate the effectiveness of a rehabilitation program with electromyographic biofeedback compared with the control group on patients with massive rotator cuff tear.

**Design:** Forty-six adults with massive rotator cuff tears, randomly assigned to 2 groups (23 electromyographic biofeedback group vs. 23 control group). The electromyographic biofeedback group (experimental group) performed the exercises under the guidance of electromyographic biofeedback, unlike the control group. All patients underwent a 45-minute training session a day, 3 times a week over a 6-wk duration, and followed up until 1-year. The outcome measures were American Shoulder and Elbow score, shoulder flexion strength, shoulder range of motion, Numeric Pain Rating Scale, and Global Rating of Change Scale.

**Results:** Compared with the control group, the electromyographic biofeedback group demonstrated a significant change in shoulder flexion strength and patient satisfaction from baseline to 6 wks (posttraining) and from baseline to 12-mo follow-up ( $F = 4.671$ ,  $P = 0.005$ ). There were significant improvements in within groups statistics for American Shoulder and Elbow score, shoulder flexion strength, shoulder range of motion, and Numeric Pain Rating Scale in both groups ( $P < 0.05$ ).

**Conclusions:** The results demonstrate that deltoid-focused structured rehabilitation program combined with electromyographic biofeedback can be used to increase shoulder flexion strength and patient satisfaction in conservative treatment of massive rotator cuff tear.

**Key Words:** Massive Rotator Cuff Tear, Nonoperative Treatment, Electromyographic Biofeedback, Deltoid, Rehabilitation, Functional Outcome

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### What Is Known

- Massive rotator cuff (RC) tears are one of the most common pathologies in the shoulder. Although a wide variety of rehabilitation programs have been studied, there is no consensus on the optimal approach and new methods need to be investigated.

### What Is New

- This is the first study investigating the effectiveness of electromyographic biofeedback on rehabilitation for patients with massive RC tear.
- Electromyographic biofeedback can be used as an alternative method that increases patient satisfaction in exercise protocols.

Rotator cuff (RC) tears are one of the most important causes of functional impairment and shoulder pain.<sup>1,2</sup> The incidence of traumatic or age-related degeneration of RC tears increases with age and reaches up to approximately 25% in individuals aged the 60s and up to 50% in 65 yrs and older.<sup>3</sup> Rotator cuff tears may be seen as a partial or full thickness.<sup>4</sup> Although it is easier to obtain improvements with conservative or surgical methods in other types of tears, repair of massive RC tears in the older population is not always possible or may require very complicated surgical procedures.<sup>5</sup> Massive RC tear has been described as a tear with a diameter of 5 cm or more by Cofield<sup>6</sup> or as a complete tear of two or more tendons as described by Gerber et al.<sup>7</sup> The treatment of massive RC tears is decided according to the age, activity level, expectation, and additional pathologies of the patient.<sup>5,8</sup>

Despite its high prevalence, there is no clear consensus on whether the most appropriate treatment approach will be surgical or nonsurgical.<sup>9,10</sup> While surgical options such as partial repair, tendon transfers, superior capsular reconstruction, and patch augmentation, are usually proposed for younger patients,<sup>11</sup> nonsurgical treatments, rehabilitation, and corticosteroid injections are frequently recommended in the elderly population.<sup>8</sup> The goals of rehabilitation programs are to make the patient functionally independent and to reduce pain.<sup>12,13</sup> Nonsurgical treatment of massive RC tear is insufficient in the literature, and there is no consensus on what treatment is more beneficial.<sup>8–10,14</sup> In biomechanical studies, it is reported that a strong deltoid muscle can compensate for the insufficiency of RC and maintain shoulder functions.<sup>15,16</sup> However, muscle strengthening requires an active process in which the patient is involved in one-on-one movement and this process is possible with the motivation of the patient.

Biofeedback is a technique that aims to improve outcomes by educating patients and actively involving them in the treatment process.<sup>17</sup> It provides additional information (feedback) about a physiological parameter and allows the individual to influence the physiological parameter based on the feedback.<sup>18</sup> Electromyographic biofeedback (EMG-BF) is a treatment modality in which a tool is used for detecting and amplifying the electrical activity of muscles and providing the patient with visual or auditory information about the magnitude of muscular tension.<sup>19</sup> Electromyographic biofeedback have shown benefit when used in part of orthopedic rehabilitation programs.<sup>20</sup> It provides visual and sensory stimuli and is one of the important tools for muscle strengthening and muscle rebuilding, especially in the elderly population.<sup>17,20,21</sup>

This study aimed to investigate the effectiveness of a deltoid-focused rehabilitation program<sup>22</sup> with EMG-BF compared with the control group on patients with massive RC tears. This study hypothesizes that the strengthening exercises performed with EMG-BF will give more positive results in terms of functional status, muscle strength, range of motion (ROM), pain, and satisfaction.

## METHODS

### Study Design and Ethics

The protocol of this clinical trial was registered at ClinicalTrials.gov (Identifier: NCT04552925). This was a single-center, prospective, with balanced randomization (1:1), parallel-group study conducted in the Department of Orthopedics and Traumatology, Istanbul University, Istanbul Faculty of Medicine. Ethical approval for this study was received from the Istanbul Faculty of Medicine, Clinical Research Ethics Committee (IRB number: 2017/08) under the Declaration of Helsinki. All the patients who accepted to participate in this study signed an informed consent form. This study conforms to all Consolidated Standards of Reporting Trials guidelines and reports the required information accordingly (see Supplementary Checklist, Supplemental Digital Content 1, <http://links.lww.com/PHM/B850>).

### Patients and Randomization

The inclusion criteria were unilateral, nontraumatic massive RC tears according to Deorio and Cofield classification,<sup>23</sup>

age older than 50 years and attending 1-yr follow-up assessment, and patients who had not received any physiotherapy program before. Nontraumatic massive RC tears were diagnosed through referred symptoms history, clinical examination, and magnetic resonance imaging by the two experienced orthopedic surgeons (KB and AE). Patients with symptomatic lesions in the contralateral shoulder, cuff tear arthropathy, glenohumeral osteoarthritis, pseudoparalytic shoulder<sup>24</sup> (elevation limited to up to 45 degrees), grade III and IV fatty degeneration according to Goutallier classification,<sup>25</sup> history of involved shoulder surgery, and major systemic conditions that disallowing exercise were excluded from the study. The tear type was limited to nontraumatic tears because nontraumatic tears are usually seen at younger ages and are treated with surgery.<sup>11,26</sup>

### Sample Size Estimation

The sample size calculation was performed by the PS Power computer program. The calculation was based on a standard deviation of 13 points, a between-group difference of 12.01 points<sup>27</sup> (which represents the minimal clinically important difference of American Shoulder and Elbow Surgeons [ASES]), an  $\alpha$  level of 0.05, a  $\beta$  level of 20%, and the desired power of 80%. These parameters generated a sample size of at least 19 patients per group. Allowing for a conservative 20% dropout rate, it was planned to recruit 46 subjects for the study.

Subjects were recruited from Istanbul Faculty of Medicine, Departments of Orthopedics and Traumatology. Fifty-eight consecutive patients diagnosed with massive RC tears were screened for eligibility. Forty-six patients met the inclusion were randomized (ratio: 1:1) using an e-randomization program (<http://www.randomization.com>). Twenty-three patients were randomized to the EMG-BF group and 23 patients to the control group.

### Outcomes

All the demographic and baseline data for each patient were recorded (Table 1). The primary outcomes of this study were the change in ASES score<sup>28</sup> and shoulder flexion strength. The ASES score<sup>28</sup> was used for functional assessment. Shoulder flexion strength was assessed with the hand-held dynamometer (Model 01165D, Lafayette Instrument,

**TABLE 1.** Demographic characteristics of participants

Variable	Control Group	EMG-BF Group	P
Men/women	5/13	4/14	0.70
Age, mean $\pm$ SD, yr	64.94 $\pm$ 7.16	62.39 $\pm$ 4.62	0.21
Height, mean $\pm$ SD, cm	161.56 $\pm$ 9.63	162.00 $\pm$ 8.73	0.48
Weight, mean $\pm$ SD, kg	80.06 $\pm$ 12.24	78.78 $\pm$ 10.85	0.40
BMI, mean $\pm$ SD, kg/m <sup>2</sup>	30.73 $\pm$ 4.59	30.13 $\pm$ 4.31	0.77
Smokers, n (%)	5 (27)	7 (38)	0.48
MRCT on dominant site, n (%)	10 (55)	9 (50)	0.31
Chronic diseases, yes/no	12/6	11/7	0.72
DM, n (%)	4 (22)	3 (16)	
HT, n (%)	8 (44)	8 (44)	

BMI, body mass index; DM, diabetes mellitus; HT, hypertension; MRCT, massive rotator cuff tear.

Co, Lafayette, IN) and was recorded in Newtons. In the sitting position, the patient flexed his shoulder at 90 degrees without the rotation in the elbow extension. The dynamometer was placed distal humerus, and the patient was asked to perform shoulder flexion against the resistance for 5 secs.<sup>29</sup> The forearm muscles have been shown to assist the anterior deltoid by providing strength from the proximal. Therefore, the dynamometer was placed on distal humerus, and force was given from the distal, in which more deltoid activity occurs.<sup>29</sup> Three measurements were performed with 30-sec rest between and averaged for evaluation. Flexion, abduction, external rotation, and internal rotation ROM were assessed with a universal goniometer. The pain was assessed by a Numeric Pain Rating Scale (NPRS).<sup>30</sup> Patients were assessed at baseline, 6th, 12th week, and at 1 yr. The Global Rating of Change Scale (GRCS) which is a 5-point Likert scale was used to evaluate patient's satisfaction end of the treatment. The GRCS was assessed at the 6th, and 12th week, and at a 1-yr follow-up.

## Interventions

The control group received shoulder ROM and stretching exercises and anterior deltoid re-education exercises described by Levy et al.<sup>22</sup> The EMG-BF group received the same exercises, but deltoid re-education exercises were performed under the guidance of EMG-BF. All subjects were treated at the clinic three times per week for 6 wks (18 sessions).

### Control Group

- Passive, active assistive, active shoulder flexion, abduction, external rotation, and internal rotation exercises in the supine position
- Shoulder active ROM exercises in sitting position or standing
- Strengthening exercises of shoulder flexion
- Strengthening exercises of external rotators and internal rotators
- Lower, middle trapezius, and serratus anterior strengthening exercises
- Posterior capsule stretching exercises
- Cold pack (10 mins)

### Electromyographic Biofeedback Group

- The same exercises in the control group were performed
- Shoulder flexion strengthening exercises were performed with EMG-BF
- Cold pack (10 mins)

The shoulder flexion strengthening exercises were initially performed with the patient in a supine position and head supported. As the patient gained confidence and strength with no pain, exercises were gradually increased from supine to sitting position (gradually weight by added). The bed inclination was initially 0 degree (lying position) and advanced to 90 degrees (sitting position) for exercise progression (30, 45, and 60 degrees, respectively). The exercises were advanced from easy to difficult according to the tolerance and progression of the patients.

In both groups, passive, active assistive, and active shoulder ROM exercises were initially performed in 2 sets and 10

repetitions and progressed to 3 sets and 15 repetitions. The strengthening exercises of the trapezius and serratus anterior were firstly started without resistance and then gradually progressed using an appropriate resistance exercise band. The exercises were started as 2 sets of 10 repetitions per day. Progressed toward 3 sets of 15 repetitions. When the patients were able to perform an exercise with 15 repetitions without pain and fatigue, the exercises progressed. Posterior capsule stretching exercises were performed in 3 repetitions (30-sec stretching 30-sec rest) for all patients, 3 sets in each session. Since the pain of the patients before treatment was approximately 5/10 NPRS and the possibility of increased pain after exercise, a cold pack was applied for 10 mins at the end of each session. In addition, the patients were asked to apply a cold pack at home. Each session was approximately 45 mins. When the 6-wk treatment with the physiotherapist in the clinic was completed, the patients were given a written form exercise program at home. Patients were invited to the clinic at once between the 6th and 12th weeks for the control and progression of the home exercise program. On the other hand, patients who could not be able to come to the clinic received a phone call to understand their progress. Patients from both groups were instructed to continue the home exercise program until 1-yr follow-up at the 12th-wk assessment.

For the EMG-BF, the 4-channel EMG-BF module of the NeuroTrac MyoPlus4 Pro was used. The sensitivity of the EMG was between 2 microvolts and 2000 microvolts. Adhesive electrodes were attached to the anterior part of the patient's deltoid muscle. During the exercises, the device was positioned so that the patient could see the games and hear the signals. The game-based EMG module was chosen to take advantage of both visual and auditory stimuli considering the age and motivation of the patients. The threshold values of the maximum electrical signals where the muscle was the loosest and the tightest were determined before each session. The thresholds during the game were adjusted accordingly to these values. Among the four games on the device, the "rabbit carrot collecting" game was preferred. Here, the patient collects the carrots with shoulder flexion, and the goal is to collect as many carrots as possible and cross all the hills in-game parkour. The patient must contract muscles on the upper threshold for the rabbit to climb the hill. At the top of the hill, the patient must pick up the carrot, otherwise, the rabbit falls. The patient performs a series of effective muscle contractions and performs arm exercises, focusing on the game. Game parkour (set) was set to consist of 5 secs of rest and 5 secs of contraction. There were 10 repetitions in each set (1 set 100 secs) and 3 sets of exercises were performed. Electromyographic biofeedback was used for approximately 15 mins during shoulder flexion exercises.

## Statistical Analysis

The normal distribution of the data was assessed by the Shapiro-Wilk test. The results of the analysis were interpreted according to the sig-2 tailed value. Parametric tests were used for the analysis of the data, which were found to be a normal distribution. Demographic characteristics (age, height, weight, body mass index), the total number of sessions, and baseline data were compared with the independent samples *t* test. The

$\chi^2$  test was used to compare the differences between categorical variables, such as sex, affected side, dominant side, and chronic diseases. The  $\chi^2$  test was also used to analyze and compare the GRCS responses of the participants at 6 wks and 1 yr.  $P < 0.05$  was considered statistically significant. For continuous variables, the mean outcome and their 95% confidence intervals were calculated at baseline and follow-up. The primary analyses,  $2 \times 4$  repeated-measures analysis of variance with time (baseline, 6-wk, 12-wk, and 1-yr follow-up, respectively). Bonferroni equality at an  $\alpha$  level of 0.05 was considered statistically significant. Intention-to-treat analysis was performed with five multiple imputations for missing values. The identified missing values were replaced by a random sample of plausible values imputations. All data were analyzed using the “IBM Statistical Package for Social Sciences (SPSS) 20.0” statistical program presented using descriptive statistics

(frequency, mean and SD). The physical therapist who performed the clinical evaluation of the patients was blinded to the group assignment. Minimal clinically important difference for the ASES score has been suggested as 12.01 points.<sup>27</sup>

### RESULTS

Throughout the intervention, 10 subjects were unable to finish the 6-wk training program for the reasons described in Figure 1 and the dropout rate was 21.74%. Therefore, 36 subjects (27 women, 9 men) completed the 6-wk planned exercise training sessions. The mean age of the EMG-BF group was  $62.39 \pm 4.62$ , and the mean age of the control group was  $64.94 \pm 7.16$ . Two patients were lost to follow-up at 1-year. There were no adverse events observed in either group during the 6-wk treatment and until the 1-yr follow-up. Demographic

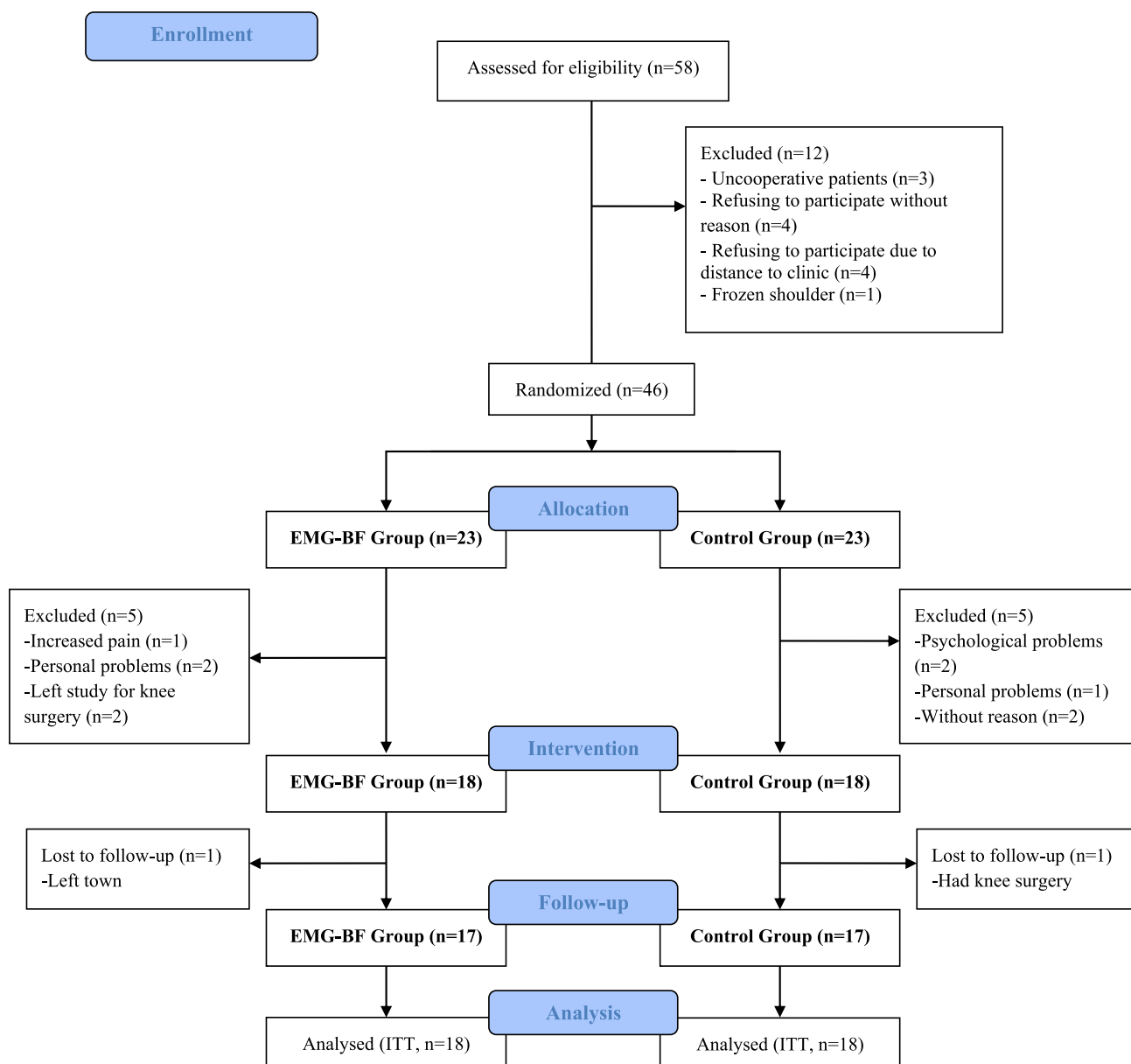


FIGURE 1. Consolidated Standards of Reporting Trials flow diagram.

**TABLE 2.** Baseline data for outcome measures in both groups

Variable	Control Group ( <i>n</i> = 18), Mean ± SD	EMG-BF Group ( <i>n</i> = 18), Mean ± SD	<i>P</i>
ASES	57.77 ± 13.63	49.69 ± 18.35	0.45
Shoulder flexion strength, N	70.55 ± 24.11	65.00 ± 20.16	0.18
Flexion ROM, degree	118.88 ± 23.92	121.11 ± 17.45	0.22
Abduction ROM, degree	109.57 ± 25.35	121.82 ± 21.96	0.69
ER ROM, degree	45.00 ± 10.58	45.83 ± 9.74	0.51
IR ROM, degree	28.44 ± 6.42	30.83 ± 5.05	0.49
NPRS	5.52 ± 1.44	4.91 ± 1.69	0.92

ASES, American Shoulder and Elbow Surgery; ER, external rotation; IR, internal rotation.

(Table 1) and baseline data (Table 2) were similar in both groups and showed a normal distribution. There was no significant difference in the sex ratio of the groups. There were significant improvements in within groups statistics for shoulder flexion strength, level of pain, ROM, and functional level for both groups ( $P < 0.05$ ). The group-by-time interaction for the  $2 \times 4$  repeated-measure analysis of variance was statistically significant for the flexion strength ( $F = 4.671$ ,  $P = 0.005$ ; Table 3). Patients receiving the EMG-BF demonstrated a greater increase in flexion strength compared with the control group (mean difference,  $-7.31$ ; 95% confidence interval,  $-22.86$  to  $8.24$  at 12 wks and mean difference,  $-7.11$ ; 95% confidence interval,  $-21.61$  to  $7.38$  at 1-yr follow-up). No significant differences were found in ASES, ROM, and NPRS scores between groups at 1-yr follow-up. According to GRCS, patients in the EMG-BF group were statistically more satisfied compared with the control group in the 6th and 12th week (Table 4). According to the results of statistical analysis, no differences were observed between groups for outcome measures at the 1-yr follow-up except shoulder flexion strength.

## DISCUSSION

The main finding of the present study is that the EMG-BF group is statistically superior in terms of shoulder flexion strength and satisfaction of the conservatively treated patients with massive RC tears compared with the control group. Although this study hypothesized that patients who were treated with EMG-BF would also have superior clinical improvements in function, ROM, and pain compared with the control group, the results of this research did not support the hypothesis.

Some of the researchers argue that conservative treatment is not a good option,<sup>31,32</sup> because of the possible tear size increase over time. However, Fucentese et al.<sup>33</sup> reported that there was no statistically significant change in the size of the conservatively treated massive RC tears over time and clinical outcomes were good. Tashjian et al.<sup>34</sup> also reported that non-surgical treatment should be tried first in elderly patients with massive and/or irreparable RC tears. In the present study, patients benefited from both conservative treatment programs at 1-yr follow-up, and none of the patients had required surgery.

When the RC is not functioning, deltoid muscle strength gains importance because torn RC cannot produce adequate flexion and abduction torque in the shoulder joint.<sup>35</sup> Therefore, the key point of nonsurgical treatment is become to strengthen the deltoid muscle. The mechanism of action of deltoid re-education in the nonsurgical treatment of massive RC tears

has been described by biomechanical studies.<sup>15,35–37</sup> Especially in elderly patients, strengthening muscles is a challenging process and requires motivation and intense effort. It is stated that the compliance of the patient with the exercise program can be increased by adding EMG-BF.<sup>20,38</sup> The authors of the current study also assumed that adding visual or auditory stimulation to rehabilitation programs could increase the motivation of participating patients especially if they are older. To our knowledge, there is no study in the literature using EMG-BF for the treatment of the nonsurgical treatment of RC tears. Deltoid-focused rehabilitation programs have been reported to be generally effective.<sup>39,40</sup> Yian et al.<sup>39</sup> found an increase of 1.1 kg in the deltoid muscle strength in the 9-mo follow-up of patients who followed the home exercise program after completing the 3-mo deltoid re-education program. Moosmayer et al.<sup>40</sup> detected a 2.5-kg improvement in deltoid strength at 6-mo follow-up, after a 12-wk physiotherapy program. However, these studies have some limitations. The authors of both studies have not specified in which position and how they evaluated muscle strength. Handheld dynamometers are one of the objective methods used to assess the strength of muscles.

In the current study, handheld dynamometer was used to assess shoulder flexion strength. The increase of 3.89, 7.54, and 7.26 N in the control group and an increase of 13.2, 20.4, and 19.92 N in the EMG-BF group were detected at 6-wk, 12-wk, and 1-yr follow-up, respectively. Because there was no minimal clinically important difference value reported for flexion strength in the past, we could not argue whether these values are clinically significant. We assume that this difference is because of the EMG-BF, which motivates patients by visual and sensory stimuli, especially during shoulder flexion. The patients may have made more effort to strengthen the muscle by receiving the signals provided by the EMG-BF. In addition, the authors of the current study think that exercises are more effective when working with the EMG-BF because compensatory patterns are minimized.

Functional limitation is a serious problem in the elderly population with massive RC tears. In studies investigating nonsurgical treatment in RC pathologies, the function was frequently assessed using ASES or Constant-Murley score.<sup>41</sup> Levy et al.<sup>22</sup> found a 37-point increase in Constant-Murley score in their studies that they applied for the anterior deltoid strengthening program. Yian et al.<sup>39</sup> found a significant increase in ASES scores in 30 of 18 patients with a 3-mo anterior deltoid re-education program. In the present study, the mean ASES score in the EMG-BF group increased by approximately

TABLE 3. One-year results for outcome scores for each group

Outcomes	Groups	6 wks, Mean ± SD		12 wks, Mean ± SD		MD (95% CI)	F	Group-by-Time Interaction
		Control	EMG-BF	Control	EMG-BF			
ASES	Control	74.36 ± 15.35	73.02 ± 14.09	81.15 ± 7.14	79.05 ± 8.35	-2.10 (-4.13 to -0.65)	1.58 (-2.99 to 0.83)	1.065
	EMG-BF	74.74 ± 23.54	78.20 ± 22.87	78.09 ± 23.69	85.40 ± 22.21	-7.31 (-22.86 to 8.24)	-7.11 (-21.61 to 7.38)	
Shoulder flexion strength, N	Control	135.55 ± 19.47	137.50 ± 18.16	141.22 ± 11.21	142.50 ± 13.20	-1.27 (-4.48 to 1.92)	-2.29 (-5.50 to 0.92)	0.87
	EMG-BF	127.89 ± 18.24	133.64 ± 18.17	133.34 ± 15.72	137.18 ± 16.69	-3.94 (-8.28 to 0.39)	-4.36 (-8.36 to -0.36)	
Flexion ROM, degree	Control	59.17 ± 6.69	58.89 ± 6.76	59.44 ± 6.40	60.28 ± 8.65	-0.83 (-2.82 to 1.15)	-0.19 (-2.09 to 1.70)	0.66
	EMG-BF	37.50 ± 4.92	35.83 ± 6.02	38.33 ± 5.66	37.78 ± 4.61	0.55 (-0.8 to 1.91)	1.76 (0.23 to 3.28)	
ER ROM, degree	Control	3.27 ± 1.97	2.72 ± 1.72	2.38 ± 1.84	1.83 ± 1.07	0.55 (0.16 to 0.95)	0.56 (0.34 to 0.78)	0.97
	EMG-BF	3.27 ± 1.97	2.72 ± 1.72	2.38 ± 1.84	1.83 ± 1.07	0.55 (0.16 to 0.95)	0.56 (0.34 to 0.78)	
NPRS	Control	49.05 ± 5.38	47.99 ± 6.32	49.05 ± 5.38	47.99 ± 6.32	0.55 (-0.8 to 1.91)	1.76 (0.23 to 3.28)	2.16
	EMG-BF	2.01 ± 0.86	1.44 ± 0.72	2.01 ± 0.86	1.44 ± 0.72	0.55 (0.16 to 0.95)	0.56 (0.34 to 0.78)	

<sup>a</sup> P < 0.05.

ABD, abduction; ASES, American Shoulder and Elbow Surgery; CI, confidence interval; ER, external rotation; IR, internal rotation; MD, mean difference; NPRS, Numeric Pain Rating Scale.

**TABLE 4.** Results of the GRCS and distribution by groups

GRCS	Control Group, n (%)		<i>P</i> <sup>a</sup>	EMG-BF Group, n (%)		<i>P</i> <sup>a</sup>	Control Group, n (%)		<i>P</i> <sup>a</sup>
	6 wks	12 wks		1 yr					
-2 (much worse)	0	0	0.01	0	0	0.01	0	0	0.16
-1 (worse)	0	0		0	0		0	0	
0 (same)	2 (11%)	0		1 (6%)	0		0	0	
+1 (better)	12 (67%)	6 (33%)		11 (61%)	7 (39%)		11 (64%)	7 (41%)	
+2 (much better)	4 (22%)	12 (67%)		6 (33%)	11 (61%)		6 (36%)	10 (59%)	

<sup>a</sup>  $\chi^2$  test.

GRCS, Global Rating of Change Scale.

24 points at the end of the 6th week and in the control group by 17 points. This increase was not significant but both groups reached the reported minimal clinically important difference value for the ASES score.<sup>28</sup>

Loss of active ROM due to muscle weakness is a serious problem in most patients with massive RC tears. The person should have 145-degree shoulder flexion and 130-degree abduction to be independent in daily life activities.<sup>42,43</sup> Levy et al.<sup>22</sup> reported that after 12 wks of anterior deltoid strengthening program applied to the patient with massive RC tears, flexion ROM reached 160 degrees in 9 mos of follow-up with an increase of 40 degrees. Yian et al.<sup>39</sup> found that after the 3-mo anterior deltoid re-education program, the flexion ROM increased from 101 to 140 degrees at 9 mos of follow-up. In the present study, ROM improvements were observed approximately 20 degrees in both flexion and abduction ROM after treatment and at 1-yr follow-up, but there was no difference between the groups.

Pain-free function acquisition is one of the important factors in patients with RC tears.<sup>44</sup> In the present study, a statistically significant reduction in pain was found in both groups similar to the literature, whereas none of the groups were superior to the other.<sup>45,46</sup> Patient satisfaction is an important parameter that evaluates the success of the treatment from the patient's perspective.<sup>47</sup> According to the published reports, nonsurgical treatment was effective in 73%–80% of patients with massive RC tear, but the actual success of the treatment was dependent on the satisfaction of patients.<sup>10</sup> In the present study, patient satisfaction was evaluated with the GRCS, and patients were asked to compare their pretreatment status with their 6th-week status. While 22% of patients in the control group stated that they were much better, this rate was 67% in the EMG-BF group. According to these results, it can be interpreted that EMG-BF assisted exercise program gives better results in terms of patient satisfaction rates in conservative treatment of massive RC tears.

There are many limitations in the studies in which nonsurgical treatments of massive RC tears are performed in the literature. Studies are not randomly controlled; the physiotherapy program is not clear, or the physiotherapy program is given only as an unsupervised home program. In addition, only 2 nonrandomized studies<sup>22,39</sup> are implementing the deltoid re-education program as a home exercises program. Therefore, it was quite difficult to compare the present study with the literature. The

present study had some strengths. First, this is one of the premise studies under the supervision of a physiotherapist in the treatment of massive RC tears. We think that it is difficult for elderly patients to exercise at home without any supervision, even if they are given exercise brochures. Second, this is one of the initial studies, in which EMG-BF was used conservative treatment of massive RC tear.

There are some limitations. This study lacks a placebo or sham control group that received no treatment whatsoever, which is restricting the ability to claim cause and effect. This study was planned as the first line of treatment for massive RC tears. Although no patients reported worsening of their symptoms at 1-yr follow-up, a magnetic resonance imaging evaluation after the treatment to compare the structural changes is not performed. Further clinical studies are needed to verify the effects over a longer follow-up and in terms of reducing the recurrence of symptoms. Because the most serious problem in these patients is shoulder elevation, EMG-BF was used for 15 mins, focusing on shoulder flexion exercises only. Further studies should focus on other exercises as well. Another limitation of the study is that the compliance rates to the home exercise program were not possible to be followed between 12 wks to 1 yr. Only verbal information was received from the patients that they did the exercises until the 1-yr follow-up. Lastly, number of participants did not reach the calculated sample size.

## CONCLUSIONS

The present study showed promising treatment effects during the rehabilitation of massive RC tears. A structured rehabilitation program combined with EMG-BF can be used as an alternative method that increases shoulder flexion strength and patient satisfaction in the conservative treatment of massive RC tears.

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