Normalization of Increased Upper Trapezius Muscle Activity with EMG Biofeedback Training in a Patient with Surgically Treated Fragmented Proximal Humerus Fracture: One-Year Follow-up Results of the Case

Proksimal Humerus Kırığının Cerrahi Olarak Tedavi Edildiği Hastada Artmış Üst Trapezius Kas Aktivitesinin EMG Biofeedback Eğitimi ile Normalize Edilmesi: Olgunun Bir Yıllık Takip Sonuçları

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Abstract

Aim: To evaluate the one-year results of the effects of electromyography (EMG) biofeedback training included in the traditional rehabilitation program on symptoms, upper trapezius muscle activity, functional status, and quality of life in a patient with surgically treated fragmented proximal humerus fracture.

Method: The patient's pain severity (Visual Analogue Scale), range of motion (Universal goniometer), grip strength (Jamar Hydraulic Hand Dynamometer), scapular position (Lateral Scapular Slide Test), fear of movement (Tampa Kinesiophobia Scale), the functional status of the upper extremity (Disabilities of the Arm, Shoulder, and Hand Questionnaire), quality of life (SF-36 Scale), upper trapezius muscle activity (surface EMG) were evaluated before and after the treatment, and at one-year follow-up. The EMG biofeedback training, which was included in the traditional rehabilitation program, was applied for eight weeks to normalize the increased upper trapezius muscle activity.

Results: It was found that pain severity and fear of movement were decreased, range of motion, grip strength, functional status of the upper extremity, and quality of life were increased after the treatment and at one-year follow-up. Also, the increased upper trapezius muscle activity was normalized and the asymmetry in the scapula position was decreased.

Conclusion: A well-planned rehabilitation program, including EMG biofeedback training, can reduce the symptoms, improve the functional status and the quality of life in a patient with surgically treated fragmented proximal humerus fracture.

Keywords: Humeral head, Fracture, EMG biofeedback, Upper trapezius, Rehabilitation

Özet

Amaç: Parçalı proksimal humerus kırığının cerrahi olarak tedavi edildiği hastada geleneksel rehabilitasyon programına dahil edilen elektromiyografi (EMG) biofeedback eğitiminin semptomlar, üst trapezius kas aktivitesi, fonksiyonel durum ve yaşam kalitesi üzerine bir yıllık sonuçlarını değerlendirmektir.

Yöntem: Hastanın ağrı şiddeti (Görsel Analog Skala), eklem hareket açıklığı (Universal gonyometre), kavrama kuvveti (Jamar Hidrolik El Dinamometresi), skapular pozisyon (Lateral Skapular Slide Test), hareket korkusu (Tampa Kinezyofobi Skalası), üst ekstremité fonksiyonel durumu (Kol, Omuz ve El Sorunları Anketi), yaşam kalitesi (SF-36 Ölçeği), üst trapezius kası aktivitesi (yüzeyel EMG) tedavi öncesi, tedavi sonrası ve bir yıllık takipte değerlendirildi. Artmış üst trapezius kas aktivitesini normalize etmek için geleneksel rehabilitasyon programına dahil edilen EMG biofeedback eğitimi sekiz hafta boyunca uygulandı.

Bulgular: Tedavi sonrasında ve bir yıllık takipte ağrı şiddeti ve hareket korkusunun azaldığı, eklem hareket açıklığı, kavrama kuvveti, üst ekstremité fonksiyonel durumu ve yaşam kalitesinin arttığı bulundu. Ayrıca, artmış üst trapezius kas aktivitesinin normale döndüğü ve skapula pozisyonundaki asimetrisinin azaldığı görüldü.

Sonuç: Parçalı proksimal humerus kırığının cerrahi olarak tedavi edildiği hastada, EMG biofeedback eğitimi içeren iyi planlanmış bir rehabilitasyon programı semptomları azaltabilir, fonksiyonel durumu ve yaşam kalitesini iyileştirebilir.

Anahtar Kelimeler: Humerus başı, Kırık, EMG biofeedback, Üst trapezius, Rehabilitasyon

Received: 03/06/2021

Accepted: 11/08/2021

Published Online: 02/12/2021

Cite this article: Yıldız NT., Kocaman H., Erden Z. Normalization of Increased Upper Trapezius Muscle Activity with EMG Biofeedback Training in a Patient with Surgically Treated Fragmented Proximal Humerus Fracture: One-Year Follow-up Results of the Case. Turk J Health S. 2021;2(3):pp.54-58.

Introduction

Proximal humeral fractures (PHF) can range from non-displaced fractures to serious fragmented head and neck fractures (1). Various treatment methods are used in PHK, including conservative treatment, Open Reduction and Internal Fixation (ORIF), and hemiarthroplasty, depending on the condition of the fracture and the patient (2). Following the surgical treatment of PHK with ORIF, upper trapezius (UT) EMG activity increases to compensate for the developing deltoid muscle inhibition. As a result, the normal kinematics of the scapula deteriorate and scapular dyskinesia occurs. Scapular dyskinesia leads to the shoulder complex working inefficiently and increases energy consumption in activities of daily living. Also, fatigue and pain occur in the muscles around the scapula and shoulder. Dynamic control of the shoulder complex is considered essential for the efficient functioning of the upper limb. The harmony of the upper and lower fibers of the trapezius muscle with the serratus anterior muscle is important for the stabilization of the scapula and to maintain the coordinated movement between the scapula and the humerus (3,4). In cases of scapula and shoulder problems, increased activity of the UT muscle compared to the middle and lower trapezius muscle is a common clinical condition. This condition first deteriorates the normal kinematics of the scapula, then causes muscular imbalance by changing the length-tension relationship between the scapula and shoulder muscles (5).

After surgical treatment of PHK with ORIF, patients could experience problems such as pain, stiffness, and loss of function that decrease the quality of life. However, it has been reported that an effective rehabilitation program applied after surgery can minimize these problems and increase the patient's functional status and quality of life (2). One of the main objectives in the rehabilitation of shoulder-related injuries is re-establishing appropriate scapular positioning during movement, which is achieved through re-training the scapular stabilizer muscles (6).

Surface electromyography (EMG) indicates the sum of motor unit action potentials detected by surface electrodes in muscles. EMG is a non-invasive evaluation method that provides information about muscles. EMG biofeedback training is used as a treatment method to improve the neuromuscular control of the affected muscles in different problems (7). It also ensures patients a better sense of the different muscle activation patterns involved in the movement of the shoulder complex. EMG biofeedback training has been used in rehabilitation programs for patients with shoulder pain in clinical settings (6).

To our knowledge, there was no study in the literature in which increased UT muscle activation was normalized

using EMG biofeedback training in patients with surgically treated fragmented PHF. In this study, it was thought that the rehabilitation program, which includes the normalization of increased UT EMG activity with EMG biofeedback training method in addition to strengthening the deltoid, serratus anterior, and lower trapezius muscles could increase the functional level and quality of life of the patient. Therefore, the purpose of this study was to examine the one-year follow-up results of the effects of an eight-week rehabilitation program, including the normalization of increased UT EMG activity with EMG biofeedback training in addition to a traditional rehabilitation program in a patient with a surgically treated (ORIF) fragmented PHF.

Case Presentation

A 63-year-old male patient occurred left fragmented PHF after a traffic accident and was surgically treated with ORIF (Figure 1). The patient, whose shoulder was immobilized for four weeks after surgery, then performed the exercises given to him at home for three weeks. Since the symptoms of pain and limitation of movement in his shoulder do not decrease, the patient applied to our clinic. This study was conducted by the Faculty of Physiotherapy and Rehabilitation, Hacettepe University, Ankara, Turkey.

Figure 1. Left side fragmented PHF (after ORIF)

After the verbal and written consent was obtained, the patient was included in an eight-week rehabilitation program that consists of evaluation and treatment methods. The pain severity, ROM, grip strength, scapular position, fear of movement, upper extremity functional status, quality of life, and UT EMG activity were evaluated before and after the rehabilitation program, and at the one-year follow-up. The severity of pain in the left shoulder during rest and activity, and at night was evaluated using the visual analog scale (VAS) (8).

The shoulder flexion, extension, external rotation, and internal rotation ROMs were measured with a Universal goniometer in the supine position. The grip strength was measured by Jamar Hydraulic Hand Dynamometer in an upright sitting position with arms adjacent to the body and elbow at 90° flexion position. The average of three measurements for the right and the left sides were recorded in kilograms (kg). The Lateral Scapular Slide Test (LSST), which is reported to be a reliable method for evaluating the scapular position, was used. The distance of the infero-medial angle of the scapula to the thoracic spine in three different positions (Position 1: arms adjacent to the body, Position 2: hands are on the iliac crests, Position 3: arms in 90° abduction) while standing was measured and recorded in cm. The asymmetry between the left and right scapular positions was examined (9).

The fear of movement with the Tampa Kinesiophobia Scale (TKS) (10), the functional status of the upper extremity with the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) (11), and quality of life with the SF-36 scale (12) were evaluated. The patient was over-activating the UT muscle during left shoulder flexion and abduction movements. It was observed that with palpation UT muscle tonus at rest and during shoulder flexion and abduction was greater than the right side. EMG activity of the left and right UT muscles was evaluated in three different positions (Measurement 1: hands on the legs and the arms adjacent to the body (in resting position), Measurement 2: at 90° shoulder flexion position, Measurement 3: at 90° shoulder abduction position) while sitting, using the “sEMG mode” of the “Chattanooga Group a Division of Encore Medical” combined electrical stimulation device. While evaluating the EMG activity of the UT, two active electrodes (recording electrodes) (Dura-stick II 1.25 inch) were placed on the surface of the “UT” muscle at 2 cm intervals and parallel to the muscle fibers. A reference electrode (passive electrode) was placed on the medial edge of the scapula (Figure 2/A) (6). The values of EMG activity at three positions were recorded in microvolts (µV). It was found that the EMG activity of the left UT muscle was significantly increased in all three positions compared to the right side (Table 1). EMG biofeedback training using the combined electrical stimulation device’s “sEMG mode” was performed for three sessions per week for eight weeks in addition to a traditional rehabilitation program to normalize the increased UT EMG activity. During the EMG biofeedback training, the patient performed two exercises, while looking at the projected EMG biofeedback column graph on the screen to see the EMG activity of UT muscle while the exercises were being performed. EMG activity of the left UT was monitored by the patient during the 90° shoulder flexion and abduction exercises. This ensured a real-time visualization of the EMG activity, while the patient performs the exercises. Through this, the patient was able to control and isolate the UT, during

the two exercises. In order to achieve a good training effect, the patient was asked to actively reduce upper trapezius EMG activity shown on the screen (6). These two exercises were progressed from one set to three sets and from 10 repetitions to 15 repetitions from active movement to resistance exercise (with Thera-band® elastic band) throughout the rehabilitation program. Also, each repetition was held for five seconds (Figure 2/B).

Transcutaneous Electrical Nerve Stimulation therapy was used for pain. Exercises were initiated with passive and active assistance to increase the ROMs, and to strengthen the deltoid, rotator cuff, lower trapezius, and serratus anterior muscles, and progressed as active and resistant exercises according to the patient’s tolerance.

Figure 2. A: Location of surface EMG electrodes, B: EMG biofeedback training during the 90° shoulder flexion exercise

It was observed that the increased upper trapezius EMG activity of the effected side decreased after the treatment program and had similar values with the non-effected side at the one-year follow-up (Table 1).

Table 1. Changes in upper trapezius muscles EMG activity

	Left UT EMG activity			Right UT EMG activity
	BT	AT	1-YF	
Measurement 1 (µV)	175-184	25-30	23-29	18-23
Measurement 2 (µV)	213-220	32-36	27-31	22-29
Measurement 3 (µV)	230-235	42-48	30-36	24-30

BT: Before treatment, AT: After treatment, 1-YF: One-year follow-up, UT: Upper trapezius, µV: Microvolt, Measurement 1: Hands on the legs and the arms adjacent to the body (in resting position), Measurement 2: at 90° shoulder flexion position, Measurement 3: at 90° shoulder abduction position

While the pain severity during rest and activity, and at night were 5, 7, and 7, respectively, according to VAS before the treatment, the patient had no pain after the treatment and at the one-year follow-up. Considerable increases were obtained in all active ROM values of the left shoulder, and left-hand grip strength after treatment and at one-year follow-up (Table 2) (Figure 3).

Table 2. Changes in ROM and handgrip strength

		Left (effected side)			Right
		BT	AT	1-YF	
Shoulder ROM (°)	Flexion	52	160	170	172
	Abduction	48	163	175	180
	External rotation	18	66	70	76
	Internal rotation	15	57	60	72
Hand grip strength (kg)		18.3	39.6	40.2	43

BT: Before treatment, AT: After treatment, 1-YF: One-year follow-up, ROM: Range of motion

Figure 3. Left and right shoulder ROMs at one-year follow-up

It was observed that the asymmetry in the position of the left scapula decreased according to the LSST after treatment and at the one-year follow-up (Table 3).

Table 3. Changes in scapular positions according to LSST

	Left Scapula			Right Scapula
	BT	AT	1-YF	
Position 1 (cm)	8	9	9.5	10
Position 2 (cm)	10	11	11.5	12
Position 3 (cm)	11	11.5	12	12.5

BT: Before treatment, AT: After treatment, 1-YF: One-year follow-up, Position 1: arms adjacent to the body, Position 2: hands are on the iliac crests, Position 3: arms in 90° abduction

After treatment and at one-year follow-up, there was a decrease in the TKS and DASH scores, and an increase in the scores of the PCS and MCS subsections of the SF-36 scale (Table 4).

Table 4. Changes in TKS, DASH, and SF-36 scale scores

		BT	AT	1-YF
TKS		39	22	20
DASH		80.17	25	6.7
SF-36	PCS	25	50	100
	MCS	22	52	100

BT: Before treatment, AT: After treatment, 1-YF: One-year follow-up, TKS: Tampa Kinesiophobia Scale, DASH: Disabilities of the Arm, Shoulder, and Hand Questionnaire, PCS: Physical Component Score, MCS: Mental Component Score

Discussion

In the present study, it was found that pain, fear of movement, and asymmetry in the scapula position were decreased, and

ROM, upper extremity functional status, and quality of life were increased in patient with surgically treated fragmented PHF after the eight-week rehabilitation program, and at the one-year follow-up.

The normal three-dimensional movement of the scapula during shoulder elevation is critical in maintaining the normal glenohumeral rhythm, preserving the subacromial space, and maximizing the length-tension relationship of the muscles. It has been reported that excessive activation of UT leads to abnormal scapular movement and deteriorates the glenohumeral rhythm (13). In patients with shoulder problems, increased UT and reduced serratus anterior EMG activity cause an imbalance in force production of these muscles, the excessive elevation of the shoulder, and the inability of the upward and posterior tilt movements of the scapula. As a result of these changes, subacromial impingement syndrome, subacromial bursitis, rotator cuff tears, and acromioclavicular joint degeneration may occur. (13).

In order to prevent these problems, it is important to ensure harmony between the shoulder and the scapula muscle activations. EMG biofeedback training can be useful to achieve this harmony. EMG feedback training has been performed in the rehabilitation of patients with nerve injury, torticollis, poliomyelitis, bruxism, and temporomandibular joint syndrome to improve the neuromuscular control of affected muscles and normalization of increased EMG activity (7). Studies have reported that positive changes in muscle activation patterns after the use of EMG biofeedback training (6).

Cleeland (14) reported that the EMG feedback training significantly reduced spasm frequency in patients with spasmodic torticollis. It has been reported that the use of EMG biofeedback training in a patient with a long-term history of the temporomandibular joint syndrome, decreased the tension in the masseter muscle and temporomandibular joint pain (15). Solberg and Rugh (16) reported that ten out of the 15 patients with bruxism showed clinical improvement as a result of EMG feedback training. Ma et al. (17) found that EMG biofeedback training is effective in providing long-term relief from symptoms of impingement. Huang et al. (18) reported that EMG biofeedback training was beneficial in improving the balance ratios of the scapular muscles. In the present study, it was found that EMG biofeedback training, which was included in the traditional rehabilitation program, normalized the increased UT EMG activity. Also, this improvement was preserved at the one-year follow-up. Our results are compatible with the aforementioned studies.

To our knowledge, this study was the first study in the literature in which used EMG biofeedback training in regulating UT muscle activation in the patient with surgically treated fragmented PHF. In this regard, this study can inspire

further studies in which EMG biofeedback training will be used in the regulation of muscle activation in surgically treated fragmented PHF.

Conclusion

The rehabilitation programs, including EMG biofeedback training, can reduce symptoms, improve functional status and quality of life in patients with surgically treated fragmented PHF. However, further long-term randomized controlled studies are needed to examine the effects of EMG biofeedback training on patients with surgically treated fragmented PHF.

Conflict of Interest: None.

Acknowledgment: We would like to thank the case for allowing us to share the details of assessment and treatment in this paper.

Ethical Approval: Informed consent (Verbal and written) was obtained from the case.

Funding: None.

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