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A Comparison of the Short-Term Efficacy of Physiotherapy Approaches in Patients with Lateral Epicondylitis

Lateral Epikondilitli Hastalarda Fizyoterapi Yaklaşımlarının Kısa Dönem Etkinliğinin Karşılaştırılması

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ABSTRACT

The study aimed to investigate the short-term effects of radial nerve self-mobilization [RNSM], manual therapy [MT], and extracorporeal shock wave therapy [ESWT] on pain, pain-free grip strength, functional status, and patient satisfaction in patients with Lateral Epicondylitis [LE] and to determine the superiority of these methods to each other. 48 patients diagnosed with LE were included in the study and were randomly divided into three groups. RNSM was applied to all patients as a home program. The first group [n=16] received only the RNSM as a home program, the MT group [n=16] received MT combined with RNSM, and the ESWT group [n=16] received ESWT combined with RNSM. The RNSM was applied five days per week, and the MT and ESWT for two sessions per week for three weeks. Pain severity, pain-free handgrip strength, functionality levels, and patient satisfaction were evaluated before and after three weeks of treatment. The pain level significantly decreased, and handgrip strength and functionality increased in all groups after three weeks [$p<0.001$]. In comparison between the groups, the decrease in pain level, the increase in maximum grip strength, and patients' overall satisfaction scores were found to be higher in the MT group than in the ESWT, and only the RNSM groups [$p<0.05$]. MT application combined with radial nerve self-mobilization exercises in the treatment of LE appears to be more effective.

Keywords: Lateral epicondylitis, radial nerve mobilization, manual therapy, extracorporeal shock wave therapy, pain

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ÖZET

Çalışmamızdaki amaç Lateral Epikondilit'te [LE] self radial sinir mobilizasyonu [RSM], manuel terapi [MT], ekstrakorporeal şok dalga tedavisi [ESWT]'nin ağrı, kavrama kuvveti, fonksiyonel durum ve hasta memnuniyeti üzerindeki erken dönem etkilerinin araştırılması ve bu yöntemlerin birbirlerine göre üstünlüğünü belirlemektir. Çalışmaya 48 LE tanılı hasta dahil edildi ve rastgele üç gruba ayrıldı. Tüm hastalara ev programı olarak RSM uygulandı. Birinci grup [n=16] sadece RSM'yi ev programı olarak, MT grubu [n=16] RSM ile birlikte MT ve ESWT grubu [n=16] RSM ile birlikte ESWT aldı. RSM haftada beş gün, MT ve ESWT ise üç hafta boyunca haftada iki seans uygulandı. Üç haftalık tedaviden önce ve sonra ağrı şiddeti, ağrısız kavrama gücü, işlevsellik düzeyleri ve hasta memnuniyeti değerlendirildi. Üç haftalık tedavi sonrasında tüm gruplarda ağrı düzeyi anlamlı olarak azalırken kavrama gücü ve fonksiyonellikte artış oldu [$p<0.001$]. Gruplar arası karşılaştırmada ise ağrı düzeyindeki azalma, maksimum kavrama gücündeki artış ve hastaların genel memnuniyet skorları MT grubunda ESWT ve sadece RSM gruplarına göre daha yüksek bulundu [$p<0.05$]. LE tedavisinde RSM egzersizleri ile kombine MT uygulamasının daha etkili olduğu düşünülmektedir.

Anahtar Kelimeler: Lateral epikondilit, radial sinir mobilizasyonu, manuel terapi, ekstrakorporeal şok dalga tedavisi, ağrı

1. Introduction

Lateral epicondylitis [LE] is one of the most common upper extremity lesions, characterized by pain in the epicondyles lateralis and forearm extensor muscles [1]. It is generally seen in those exposed to repetitive wrist extension, forearm pronation-supination, and vibrations. There is a reported prevalence of 1-3% in the general population, and it is seen more often between the ages of 30-60 years, primarily in females and on the dominant side [2,3]. Symptoms of LE are seen as tenderness on the lateral epicondyle, pain with resistant middle finger extension and wrist extension, a decrease in pain-free grip strength, and difficulty in daily living activities [4].

Many conservative therapies have been used in the treatment of LE, and no standard protocol is documented in the literature [4-6]. The general principle in LE is to relieve pain, accelerate recovery, increase function, and ensure a rapid return to daily life activities. Most patients can recover with conservative treatment. Surgical treatment is indicated in 5-10% of patients whose symptoms do not improve with conservative treatment [4]. Treatment procedures include modifications of daily life activities, exercise, manual therapy, orthosis, taping, laser treatment, extracorporeal shock wave therapy, and pharmacotherapy [2, 4-7].

Exercise therapy, including radial nerve mobilization exercises, has been used to treat musculoskeletal problems, including LE [8,9]. Nerve mobilization or neurodynamics mobilization, defined by David Butler, is aimed at restoring homeostasis in and around the nervous system through facilitating movement between neural structures and their surroundings. It is stated that neural shifting reduces adhesions between the nerve and surrounding tissue, improves neural vascularity, and improves the axoplasmic flow [9-11]. Manual therapy [MT] increases joint and soft tissue mobility by stimulating mechanoreceptors. By stimulating the mechanoreceptors, the mechanical effect enables

the collagen fibrils to regain the ability to glide over scar tissue and increase joint mobility. It has been reported that in this way, articular structures increase flexibility and tissue strength, and these effects are utilized in LE. The biomechanical effects seen help to reveal indirect neurophysiological responses. Receptor nerve endings in periarticular structures affect pain, proprioception and muscle relaxation. Matrix production is stimulated, circulation increases, histamine release decreases and reflex sympathetic effect is inhibited. This reduces pain and protective muscle spasm. With increased intra-articular movement, synovial fluid movement is stimulated, edema is reduced with increased circulation and intra-articular structures are nourished [12-14]. In the 1990s, extracorporeal shock wave therapy [ESWT], developed for soft-tissue problems, was widely used in the treatment of musculoskeletal problems. Although the analgesic effect of ESWT has not been fully elucidated, it is widely accepted that shock waves cause hyperstimulation analgesia of nerve endings at the painful point. It is thought to contribute to the analgesic effect by increasing cell membrane permeability, blocking nociceptors, reducing neuropeptides such as Substance P and calcitonin gene-related peptide (CGRP) [15]. Although the current level of evidence for ESWT is largely unknown yet, the success rate of treatment varies between 65% and 91% [16].

Since lateral epicondylitis as a common disease results in economic losses, efficient, safe, and easily applicable treatment approaches should be preferred. Most patients diagnosed with lateral epicondylitis can be effectively managed with non-surgical treatment. There are numerous studies for the non-surgical treatment of LE, but the current literature does not provide conclusive evidence for the treatment of LE. Therefore, the aim of this study was to determine the short-term effects of RNSM, MT, and ESWT approaches on pain, pain-free grip strength, functional status and patient satisfaction in patients with LE; to evaluate the superiority of these approaches to each other. The hypothesis of the study was that there would be a difference in respect to pain, pain-free grip strength and functionality between the results.

2. Material and Method

This randomized, controlled study was conducted in the Malatya Training and Research Hospital Department of Physiotherapy and Rehabilitation. Participants randomized the list in order of arrival method was divided into groups. The study was approved by the Hasan Kalyoncu University School of Health Sciences Non-Interventional Research Ethics Committee [2018-5]. All the subjects were given an explanation of the study and signed a consent form before the examination.

Participants

Volunteer patients older than 18 years of age with a diagnosis of LE were included in the study. The study inclusion criteria were defined as follows; the patients had complaints of pain and tenderness on and around the lateral epicondyle and increased pain with resistant elbow extension, wrist extension, gripping, and supination. The study exclusion criteria were defined as follows: patients with tendon rupture, limited joint movement as a result of known ulna, radius or humerus fracture, undergoing surgery in the elbow region, using painkillers, with bilateral symptoms, cardiac arrhythmia or pacemaker, nerve or nerve root compression, local dermatological problems, with diabetes mellitus or neurological problems, and those who had received physical therapy and injections in the last six months. The first group received only the RNSM exercise as a home program. The MT group received the same RNSM combined with MT. The third group received ESWT combined with the same RNSM.

Interventions

Radial Nerve Self Mobilization [RNSM] group: All the patients in the study received general training about the mechanism of LE, progression, and preventative measures. The patients were also taught how to apply home exercises comprising radial nerve mobilization. While applying radial nerve self-mobilization, the patient was in a standing position, depressed the shoulder and rotated the shoulder internally, extended elbow, turned wrist flexion and towards the ulnar deviation, looked towards the

hand, and held at it for 5 seconds before returning to the initial position [Fig. 1a] [9]. These exercises were to be performed at home five days a week, with ten repetitions in each session for a total of three weeks. Once a week, a reminder message was sent to all the patients.

Manual Therapy [MT] group: For the MT group, in conjunction with RNSM, MT techniques were applied two days a week for three weeks by the physiotherapist [SC], who was seven years of clinically experienced and was trained in manual therapy. Deep friction massage was applied to the extensor carpi radialis brevis muscle in transverse direction for 5 minutes, with the patient in a comfortable position on the bed, elbow flexed, and forearm in pronation. For joint mobilization, starting with cervical tractions, mobilizations were applied to the distal and proximal radio-ulnar and humero-ulnar joints at grade 1-2 intensity. Mobilization oscillations 1-2/sec., 5 sets and 20 sec each set. was in the form. [Figure 1b-f] [2, 7,13].

Figure 1. Mobilization techniques applied to patients; **a:** mobilization of radial nerve **b:** deep friction massage **c:** mobilization of the humeroulnar joint **d:** mobilization of the humeroradial joint **e:** mobilization of the proximal radioulnar joint **f:** mobilization of thedistal radioulnar joint.

Extracorporeal Shock Wave Therapy [ESWT] group: Similarly, in conjunction with RNSM, a total of six ESWT sessions were applied two days a week for three weeks by the physiotherapist [SC]. The ESWT therapy was applied at 8 Hz frequency, 1.8 bar intensity, and 2000 beats using a Swiss DolorClast® Master ESWT device [EMS SA, CH, Nyon, Switzerland] [16]. ESWT was applied to the lateral epicondyles and the sensitive points around them. As the area of application is narrow, to minimize complications, low pressure was preferred. The patients were followed up until the end of the study, and no local tissue effect was reported.

Outcome measures

The demographic information, affected side and duration of complaints was recorded for all the patients at baseline before the treatment. Evaluations were made of pre-and post-treatment pain intensity, wrist ROM, hand and finger grip strength, functional status of the upper extremity, and patient satisfaction.

Pain severity: This was evaluated using a Visual Analog Scale [VAS]. On a 10 cm horizontal line, the patients indicated the pain level at rest, during activity, and at night before the treatment at baseline, and at the end of 3 weeks following the last treatment [17].

Pain-free handgrip strength: Pain-free maximum grip strength was taken with a hand dynamometer [Baseline Hydraulic Hand Dynamometer, Irvington, NY, USA]. The test was measured until the

patients felt discomfort. The pain-free maximum grip strength test was performed in two positions of the elbow. First, the patient is seated with the shoulder in adduction, the elbow in 90° flexion, the forearm neutral, and the wrist in 0-30° extension and 0-15° ulnar deviation, and the second measurement was taken on the elbow in the extension [18]. The measurements were repeated three times at the affected side at 30-second intervals, and the average of the measurements was taken for analysis. Values were recorded in the kg-force.

Level of functionality: The Turkish version of the Disabilities of the Arm, Shoulder, and Hand [DASH] was used to assess upper extremity functions [19]. The questionnaire consists of three sections, 38 questions in total related to symptoms and activities of daily living scored on a 5-point system. The maximum score is 100, and higher scores indicate greater disability.

Patient satisfaction: The Turkish version of the Patient Satisfaction Questionnaire Short Form [PSQ-18] was used to assess the patient's overall satisfaction with the treatment. PSQ-18 consists of seven scales general satisfaction, technical quality, interpersonal attitude, communication, financial aspects, time spent with the health care provider, accessibility, and convenience. Each item is scored between 1-5 [20]. The PSQ-18 was administered at the end of 3 weeks following the last treatment.

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM® SPSS© 21.0 software [SPSS Inc., Chicago, IL, USA] [21]. Descriptive statistics were presented as mean±standard deviation values and number [n] and percentage [%]. Categorical variables were compared using the Pearson Chi-Square Test and Fisher's Exact Test. Conformity of the variables to normal distribution was assessed with the Shapiro-Wilk Test. In comparisons between three independent groups, the one-way ANOVA test and posthoc Tukey test were applied when data were homogenous. The Welch test and posthoc Tamhane test or Kruskal-Wallis test were used in case of nonhomogeneity. Homogeneity was examined using Levene's test. The Paired T-test was used for normally distributed variables to compare pre and post-treatment values in two dependent groups. Relationships between categorical variables were examined with Spearman correlation analysis. A value of $p < 0.05$ was considered statistically significant in all analyses. Power analysis to calculate the sample size was applied using G-power 3.19 software. A moderate effect size [effect size = 0.5] was set based on Cohen's d, and the significance level was set to a = 0.05 and power = 0.8, resulting in a minimum of 15 subjects per group required [22].

3. Results

52 of the patients eligible to participate in the study, four patients were excluded because they could not continue with the treatments, so the analysis was made of 48 patients [31 females, 17 males] [Figure 2].

Demographic Findings

There was no significant difference between the groups in terms of age, gender, weight, height, dominant side, affected side, occupation, and duration of complaints [$p>0.05$] [Table 1]. There was a significant, positive, and moderate relationship between the dominant and affected sides [$r=0.334$; $p=0.020$].

Clinical Findings

Pain severity: A statistically significant decrease was observed in pain symptoms during rest, activity, and at night after treatment in all three groups [$p<0.001$] [Table 2]. Comparing the groups there was no significant differences between the groups at the beginning of the therapy [$p>0.05$] [Table 3]. After 3 weeks of treatment a statistically significant decrease was found in pain symptoms during rest [$p=0.006$], activity [$p=0.000$], and at night [$p=0.003$] between the groups [Table3]. In the comparison of

the post-treatment pain values, a significant difference was determined between the groups RNSM - MT [p=0.010] and MT-ESWT [p=0.023]. There were no significant differences between the RNSM-ESWT group in all pain symptoms during rest [p=0.948], activity [p=0.344], and at night [p=0.992] [Table 4].

Pain-free handgrip strength: A significant increase was observed in all handgrip strength measurements after treatment on the affected side in all three groups [p=0.000] [Table 2]. Comparing the groups there was no significant differences between the groups at the beginning of the therapy [p>0.05] [Table 3]. Comparing the groups there was no differences at the beginning of the study. After treatment period a statistically significant decrease was found in maximum grip [p=0.025], and painless grip [p=0.034], at elbow extension, and painless grip at elbow flexion [p=0.026] between the groups [Table3]. In the evaluation of the post-treatment, a statistically significant difference was found in the MT group in terms of maximum grip in elbow extension [p=0.034], painless grip in elbow extension [p=0.026], and painless grip in elbow flexion [p=0.020] on the affected side compared to the ESWT group. No difference was seen between the RNSM and MTgroups [p>0.05] and between RNSM and ESWT [p>0.05] groups [Table 4].

Level of functionality: DASH measurements were found to be statistically significantly decreased in all three groups after treatment [p=0.000] [Table 2]. No statistically significant difference was found between the groups at the baseline [p=0.711] and after treatment [p=0.489] evaluation of DASH scores [Table 3].

Patient satisfaction: There was a difference in the PSQ-18 parameters of mean ‘’overall satisfaction’’ and ‘’mean time spent with a healthcare provider’’ levels after the treatment [p<0.05] [Table 2]. A statistically significant difference was determined in the MT group compared to RNSM and ESWT groups [p<0.05] [Table 4].

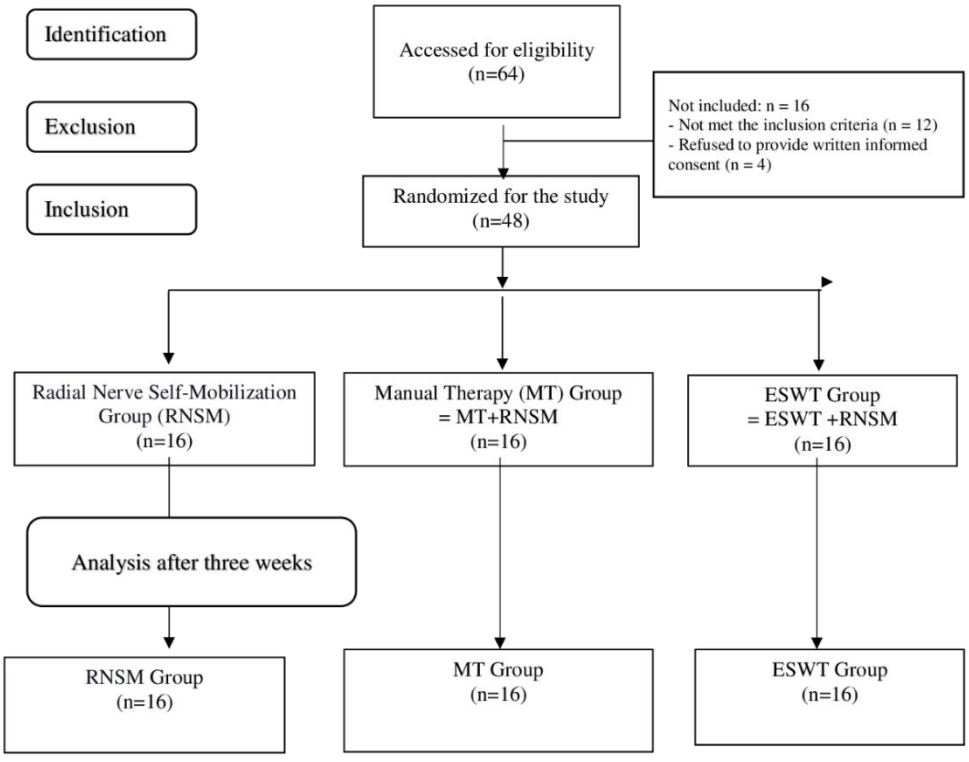

Figure 2: Flow diagram of the study

Table 1: Comparison of demographic characteristics of the groups

		Home program group [n=16]	Manual therapy group [n=16]	ESWT group [n=16]	Toplam [n=48]	F	P
Age [year] [X±SS]		45,43±10,43	45,93±9,11	46,81±11,15	46,06±10,06	0,074	0,929[a]
Gender N[%]	Female	11 [%68,8]	9 [%56,3]	11[%68,8]	31 [%64,6]		0,695[b]
	Male	5 [%31,3]	7 [%43,8]	5 [%31,3]	17 [%35,4]		
Weight [kg] [X±SS]		72,31±11,85	75,43±9,55	70,37±13,79	72,70±11,79	0,742	0,482[a]
Height [cm] [X±SS]		167,25±8,52	169,12±8.56	164,12±10,09	166,83±9,13	1,235	0,300[a]
Dominant Side N[%]	Right	14 [%87,5]	14 [%87,5]	13 [%81,3]	41 [%85,4]		1,000[c]
	Left	2 [%12,5]	2 [%12,5]	3 [%18,8]	7 [%14,6]		
Affected Side N[%]	Right	12 [%75,0]	11 [%68,8]	9 [%56,3]	32 [%66,7]		0,519[b]
	Left	4 [%25,0]	5 [%31,3]	7 [%43,8]	16 [%33,3]		
Working conditions N[%]	Housewife	7 [%43,8]	6 [%37,5]	7 [%43,8]	20 [%41,7]		1,000[c]
	Working	3 [%18,8]	4 [%25,0]	3 [%18,8]	10 [%20,8]		
	Retired	3 [%18,8]	3 [%18,8]	2 [%12,5]	8 [%16,7]		
	Others	3 [%18,8]	3 [%18,8]	4 [%25,0]	10 [%20,8]		
Complaint period [months] [X±SS]		6,94±3,13	6,56±2,80	7,75±3,89	7,08±3,27	0,539	0,587[a]

a: One-way ANOVA test, b: Chi-square test, c: Fisher's exact test

Table 2: Intragroup changes of measurements before and after treatment

		Home program group				Manual therapy group				ESWT group			
Pain [VAS]	Rest	**Pre-T**	**Post-T**	**t**	***p***	**Pre-T**	**Post-T**	**t**	***p***	**Pre-T**	**Post-T**	**t**	***p***
		3,25±1,34	1,97±0,96	4,873	**0,000[a]**	4,06±1,38	1,09±0,88	12,710	**0,000[a]**	3,51±1,21	2,07±0,87	6,043	**0,000[a]**
	Activity	6,90±1,06	4,80±1,30	5,195	**0,000[a]**	7,31±1,08	3,64±0,79	16,793	**0,000[a]**	7,39±1,02	5,38±1,35	6,631	**0,000[a]**
	Night	3,58±1,15	2,65±1,10	4,358	**0,001[a]**	4,57±1,89	1,65±0,72	14,411	**0,000[a]**	3,96±1,04	2,69±0,82	5,592	**0,000[a]**

Hand grip strength	Affected side	Maximum grip at elbow extension	23,70±7,06	26,55±7,54	-5,781	**0,000[a]**	24,47±7,39	28,37±8,17	-8,305	**0,000[a]**	21,33±6,33	23,76±7,00	-5,977	**0,000[a]**
		Maximum grip at elbow flexion	21,80±6,88	24,08±7,46	-4,138	**0,001[a]**	21,99±7,16	24,89±7,70	-6,485	**0,000[a]**	18,64±6,28	22,58±9,51	-2,094	**0,054[a]**
		Painless grip at elbow extension	19,74±6,43	22,22±7,39	-5,227	**0,000[a]**	19,35±6,72	25,26±7,60	-9,085	**0,000[a]**	16,60±5,57	18,49±6,27	-4,315	**0,001[a]**
		Painless grip at elbow flexion	18,53±7,65	19,68±6,64	-1,421	**0,024[a]**	17,47±6,65	23,06±7,12	-7,945	**0,000[a]**	14,76±5,35	16,60±5,67	-6,003	**0,000[a]**
Finger grip	Effect side	Lateral finger grip	3,12±0,76	3,99±0,87	-5,450	**0,000[a]**	3,30±0,81	4,49±0,97	-8,715	**0,000[a]**	3,16±0,74	4,03±0,90	-5,659	**0,000[a]**
		Fingertip grip	1,93±0,64	2,62±0,59	-5,126	**0,000[a]**	1,87±0,59	2,74±0,79	-8,322	**0,000[a]**	1,91±0,50	2,70±0,76	-7,559	**0,000[a]**
DASH			43,94±6,03	35,46±5,41	5.549	**0,000[a]**	45,42±5,65	33,53±4,71	6.771	**0,000[a]**	45,33±5,27	35,17±4,47	10.662	**0,000[a]**
PSQ-18	Overall satisfaction		4,31±0,47				4,54±0,34				4,15±0,30			**0,021[b]**
	Technical quality		4,53±0,40				4,67±0,29				4,48±0,44			0,371[b]
	Interpersonal attitude		4,96±0,12				5,00±0,00				4,96±0,12			0,610[b]
	Communication		4,62±,0,34				4,65±0,35				4,53±0,34			0,569[b]
	Financial dimensions		5,00±0,00				4,93±0,17				4,93±0,17			0,344[c]
	Health Service		4,56±0,30				4,93±0,17				4,71±0,25			**0.000[d]**
	Accessibility and comfort		4,65±0,30				4,62±0,32				4,71±0,30			0,688[b]
	Total		83,62±3,87				85,56±2,58				84,37±2,65			0,221[d]

*p<0.05; a: Paired T test, b: One-way ANOVA test, c: Kruskal-Wallis test, d: Welch test.

ESWT: Extracorporeal Shock Wave Therapy, **VAS:** Visual Analog Scale, **Pre-T:** Before treatment, **Post-T:** After treatment, **DASH:** Disabilities of the Arm, Shoulder, and Hand, **PSQ-18:** Patient Satisfaction Questionnaire Short Form.

Table 3: Comparison of the evaluation parameters between groups before and after treatment

		Evaluation criteria	Measurement periods	Home program group	Manual therapy group	ESWT group	F	p[a]
				(X±SS)	(X±SS)	(X±SS)		
PAİN (VAS)		Rest	Pre-T	3,25±1,34	4,06±1,38	3,51±1,21	1,588	0,216[a]
			Post-T	1,97±0,96	1,09±0,88	2,07±0,87	5,666	**0,006** [a]
		Activity	Pre-T	6,90±1,06	7,31±1,08	7,39±1,02	0,976	0,385[a]
			Post-T	4,80±1,30	3,64±0,79	5,38±1,35	9,083	**0,000** [a]
		Night	Pre-T	3,58±1,15	4,57±1,89	3,96±1,04	3,135	0,053 [a]
			Post-T	2,65±1,10	1,65±0,72	2,69±0,82	6,841	**0,003**[a]
Hand grip strength	Affected side Affected side	Maximum grip at elbow extension	Pre-T	23,70±7,06	24,47±7,39	21,33±6,33	0,892	0,417
			Post-T	26,55±7,54	28,37±8,17	23,76±7,00	1,493	**0,025**
		Maximum grip at elbow flexion	Pre-T	21,80±6,88	21,99±7,16	18,64±6,28	1,234	0,301
			Post-T	24,08±7,46	24,89±7,70	22,58±9,51	0,322	0,727
		Painless grip at elbow extension	Pre-T	19,74±6,43	19,35±6,72	16,60±5,57	1,197	0,311
			Post-T	22,22±7,39	25,26±7,60	18,49±6,27	3,635	**0,034**
		Painless grip at elbow flexion	Pre-T	18,53±7,65	17,47±6,65	14,76±5,35	1,38	0,262
			Post-T	19,68±6,64	23,06±7,12	16,60±5,67	3,942	**0,026**
Finger grip		Lateral finger grip	Pre-T	3,12±0,76	3,30±0,81	3,16±0,74	0,259	0,773
			Post-T	3,99±0,87	4,49±0,97	4,03±0,90	1,453	0,245
		Fingertip grip	Pre-T	1,93±0,64	1,87±0,59	1,91±0,50	0,05	0,951
			Post-T	2,62±0,59	2,74±0,79	2,70±0,76	0,122	0,885
DASH			Pre-T	43,94±6,03	45,42±5,65	45,33±5,27	0,343	0,711
			Post-T	35,46±5,41	33,53±4,71	35,17±4,47	0,726	0,489

p<0.05; a: F: One-way ANOVA test

Table 4: Differences in variation of measurements between groups

			Home program group - Manual therapy group	Manual therapy group -ESWT group	Home program group - ESWT group
			p[a]	p[a]	p[a]
Pain [VAS]		Rest	**0,010**	**0,023**	0,948
		Activity	**0,021**	**0,000**	0,344
		Night	**0,008**	**0,006**	0,992
Hand grip strength	Affect side	Maximum grip at elbow extension	0,321	**0,034**	0,343
		Painless grip at elbow extension	0,454	**0,026**	0,309
		Painless grip at elbow flexion	0,316	**0,020**	0,381
PSQ-18		Overall satisfaction	0,204	**0,016**	0,485
		Health Service	**0,001**	**0,026**	0,343

*p<0.05; a: Tukey Post-hoc test
ESWT: Extracorporeal Shock Wave Therapy, **VAS:** Visual Analog Scale, **PSQ-18:** Patient Satisfaction Questionnaire Short Form.

4. Discussion and Conclusion

The results of this study demonstrate that all groups, the RNSM group as a home program, RNSM combined with soft and joint mobilization (MT group), and RNSM combined with ESWT (ESWT group), experienced significant improvements in pain, pain-free grip strength, functional status and patient satisfaction following three weeks treatment. The MT group experienced significant outcomes for all variables compared to those receiving only RNSM and ESWT group treatment. The MT group had the combination of deep friction massage, humeroradial, humeroulnar, proximal and distal radioulnar joint, and cervical traction, in conjunction with a home program of radial nerve mobilization was determined to be the most effective treatment method for pain reduction, pain-free grip power, increased functionality, and patients' overall satisfaction scores. We hypothesized that there would be a difference in pain, pain-free grip strength, and functionality between the groups' results. Considering these results, we confirmed the hypothesis of our study.

It has been suggested that inflammation of the extensor digitorum muscle tendons of the wrist causes reactive synovitis and fibrosis in the annular ligament in LE. The local edema increases the pressure on the radial nerve [2, 9]. Studies pointed out that the pain level and loss of grip strength will affect the upper extremity functionality in patients [8-10]. Therefore, the pain level and grip strength are used as valid tests to evaluate the effect of treatment. Neural mobilization exercises performed on patients with LE reduce pain by reducing pressure on the neural tissues and providing an appropriate physiological function range. According to Butler, nerve mobilization increases the nerve's sliding ability and blood supply, providing healing [10]. On the other hand, different results appear in the literature. Yilmaz et al. [9] reported that the neuro mobilization technique did not increase grip strength but decreased pain level. Vilfane et al. [23] suggested that nerve mobilization increases grip strength but found no significant difference between the groups.

In our study, effective results were obtained in all groups. All three groups in this study were given nerve mobilization exercises as a home program. Even in the first group that underwent only RNSM, it was observed that the active nerve mobilization of the patients effectively reduced the pain and increased maximum grip strength. We believe the mobilization of the radial nerve has increased the sliding ability of the nerve and decreased the pressure on the nerve and around the tissue. Therefore, decreased pain level may have increased grip strength.

The effect of MT approaches has been demonstrated in the literature. Studies have recommended manual therapy alone or as part of multimodal physical therapy interventions in patients with LE [6,7,14]. Richer et al. [14] suggested that wrist mobilizations were influential in the long and short-term improvement of pain and functional status. Hoogvliet et al. [7] reported that exercise and joint mobilization could be applied together with other medial and lateral epicondylitis therapies. Evidence suggests that mobilization positively affected pain and functional capacity and pain-free maximum grip strength scores compared to the control group [12,24]. Yi et al. [25] reported a significant difference in pain reduction with deep friction massage for two weeks compared to the other groups.

Our findings agree with the results of the literature, indicating the effectiveness of MT treatment in LE patients. As there was a significant reduction in pain and increased maximum grip strength in the MT group in our study, soft tissue, and joint mobilizations can be considered one of the effective treatment methods for reducing pain, similar to the literature mentioned above. MT is a complex intervention involving multiple interactions of complementary mechanisms. It works through biomechanical and neurophysiological mechanisms [26]. Bialosky et al. postulate that an MT intervention results in neurophysiological responses within the peripheral and central nervous systems responsible for pain inhibition [27]. In our study, we proposed that the mobilization of the soft tissue and joints with combined RNSM may reduce pain and increase functionality through biomechanical and neurophysiological mechanisms.

There has been increasing in the number of ESWT studies over the years. However, conflicting study results are seen in the literature. Different application methods and parameters were used in the studies [22, 28-32]. For this reason, the results of the studies differ, and no definite results can be given about the effectiveness of shock waves. While some studies report that ESWT is not superior to the control group [15,28], other studies show that this application is especially effective in healing inflamed tendon problems [16, 29-31]. Yao et al. [16] compared 501 patients who applied with ESWT and 534 patients with other methods and reported that the ESWT application effectively reduced pain and improved finger grip strength. In the comparison of various techniques, one study reported the

superiority of ESWT application over the laser [29], corticosteroid injection [30], and wrist splint [31]. Haake et al. [15] conducted an active ESWT and placebo study on 30 LE patients. They gave three treatments weekly and found no differences between treatment groups. Significantly more side effects like skin reddening, pain, and small hematoma were documented in the active ESWT group than in the placebo group. In the current study, we performed two ESWT applications a week, for three weeks and did not see any side effects, and our patients did not report any complaints during or after the treatment. ESWT group was found to be effective after three weeks in all measurements. However, when we compared the groups, the MT group was influential in pain, pain-free grip strength, and patient satisfaction. The MT group experienced significant outcomes compared to those receiving ESWT, and home program groups. Moreover, there was no statistical significance between the RNSM and the ESWT groups.

The pain and decreased grip strength in patients with LE can affect functionality. In the current study, we used the DASH to measure the functionality of the upper extremity. Studies have demonstrated improvement in the upper extremity function following eccentric exercises [32], and nerve mobilization exercises [33]. Similarly, in the current study, DASH measurements were significantly decreased in all three groups after the treatment period. Although there was no statistically significant difference between groups, the DASH functionality value was found lowest in the MT group following three weeks treatment. In addition, it was observed that the patient's overall satisfaction levels from the treatment were higher in the MT group. Patient satisfaction is most often mentioned in healthcare institution management literature and has become a leading subject examined in the research. In the current study, patient satisfaction was evaluated with the PSQ-18. The results showed that in the parameter of “time spent with the healthcare provider,” the values of the MT group were higher than those of the other two groups. This difference was thought to be due to the longer time spent with the patient and that touching the patient during the application was influential on the pain and other values.

Although many medical and conservative methods are used for lateral epicondylitis, there is no definite consensus about the effectiveness of these treatments. In this study, we aimed to determine the short-term effects on pain, pain-free grip strength, and functionality of three different approaches discussed in the literature and to evaluate the superiority of these to each other. This study can be considered that treatment interventions treating patients with LE were influential in the short term in all study groups. Comparing the results, MT including soft tissue and joint mobilizations supported with RNSM, was the most effective treatment protocol in LE treatment. It was thought that there might be some differences between the groups which did not emerge in the short term but would be seen after the long-term follow-up. Therefore, there is a need for longer-term follow-up to better understand the efficacy of these treatment methods.

Limitations of the Study

The patients included in the study had ongoing complaints for 2 -17 months. This range includes subacute and chronic periods, which could affect the efficacy of the treatment. Also, radial nerve mobilization exercises given as a home program made follow-up of the patients more difficult. Although the follow-ups are made with weekly controls, we can say that the exercises may have 5-10% margin of error as a limitation. Moreover finally, although early results of the treatment were seen, the follow-up period of 3 weeks can be considered short.

Declaration of Ethical Code

In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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