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Original Article

Effect of Electro-Acupuncture in Chronic Rotator Cuff Tendonitis Patients : A Randomized Controlled Trial.

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Abstract

Purpose: This study purpose to investigate the effect of electro-acupuncture (EA) on pain intensity level, shoulder abduction, internal and external rotation ROM, and functional disabilities level in CRCT patients.

Materials and Methods: Sixty-six participants, aged from 18 to 65 with CRCT and BMI from 18.5 to 24.9 kg/m², were enrolled and randomly assigned to a control group (n = 33) receiving conventional physical therapy or an experimental group (n = 33) receiving the same conventional physical therapy plus EA. Pain intensity level, ROM for abduction, internal, and external rotation, and shoulder functional disabilities level were assessed using the Visual Analog Scale (VAS), a smartphone clinometer, and the Arabic version of the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH),respectively.

Results: each group showed significant improvements in VAS and DASH scores and shoulder ROM after treatment compared to baseline. The experimental group demonstrated greater improvements in VAS, DASH scores, and ROM for abduction, internal, and external rotation than the control group.

Conclusion: EA appears to be an effective adjunctive therapy for CRCT, enhancing pain management, ROM, and functional outcomes. Integrating EA with physical therapy may improve patient outcomes in CRCT management.

Keywords: Chronic Rotator Cuff Tendonitis; visual analogue scale; Smartphone clinometer application; The Disabilities of the Arm; Shoulder and Hand questionnaire; Electro-acupuncture.

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Introduction:

The Rotator Cuff muscles is a group of four muscles including Supraspinatus, Infraspinatus, Subscapularis and Teres minor. The primary function of the Rotator Cuff muscles is to hold the humeral head in the glenoid cavity of the scapula during all movements of the

Glenohumeral joint. Chronic Rotator Cuff Tendonitis (CRCT) is the inflammation of any or all of the Rotator Cuff tendons due to overuse or impingement for more than three months **(1).**

Chronic Rotator Cuff Tendonitis is one of the main causes of shoulder pain. It represents a substantial portion (15-50%) of shoulder pain disorders. It is associated with inflammation, Stress, degeneration including Impaired and disorganized Collagen, poor mechanics and is generally caused by overuse. The most common symptoms in CRCT are persistent shoulder pain which worsens with activities that involve overhead movements or lifting the arm, painful arc of motion which is a painful shoulder abduction from 70 to 120 degrees, reduced shoulder range of motion (ROM) particularly shoulder abduction, internal rotation and external rotation movements leading to shoulder functional disabilities **(2).**

Electro-acupuncture (EA) is a combined application of traditional medicine (acupuncture) and modern medicine (electric stimulation), allows the Stimulation of a larger area around the acupoint for a shorter time and, especially, allows parameters such as intensity, duration, and frequency of the stimulus to be easily identified and quantified **(3).**

Electro-acupuncture on the affected tissue controls systemic inflammation by inducing a vagal activation of Dihydroxyphenylalanine decarboxylase leading to the production of dopamine in the adrenal medulla. Dopamine inhibits cytokine production via dopaminergic type-1 receptors, Dopaminergic D1-agonists suppress systemic inflammation **(4)**.

Additionally, studies have found that EA Improves joint function **(5),** improves limb muscle strength (**6)** and has a significant analgesic effect **(7).**

Materials and Methods:

This study was conducted from October 2023 to June 2024 at the Outpatient Clinic of Faculty of Physical Therapy, Cairo University, Egypt and the outpatient clinic of Faculty of Physical Therapy, Egyptian Chinese University, Egypt. The ethical approval was obtained from the institutional review board of the Faculty of Physical Therapy at Cairo University (with the reference number P.T.REC/012/004473). All participants signed a written consent form after receiving full information about the purpose of the study with the assurance that they could withdraw their participation at any time without consequences.

Study Design

Single blinded randomized controlled trial, pretest - post measurements.

Participants

The sample size for this study was 66 patients divided randomly into two groups (n=33 in each group). Sample size was determined through applying G Power (version 3.1.9.7). Calculation was based on t-test, the type I error rate was set at 5% (alpha-level 0.05).

Type II error rate was at 80% power. The sample was randomly divided into two groups (control group) and (experimental group) using opaque, sealed envelopes, each containing the name of one of the groups.

Control group: went through a conventional physical therapy program (8).

Experimental group: went through a conventional physical therapy Program In addition to EA intervention. Each participant was diagnosed as CRCT and referred by Orthopedists. After inclusion in the study, each participant signed a consent form, personnel data, past medical history, were collected at the beginning of the study.

Measurements were conducted before and after six weeks (two sessions per week) of the intervention.

Inclusive Criteria

Participants included in the study were adults aged from 18 to 65 years with a clinical diagnosis of chronic rotator cuff tendonitis, confirmed by special clinical tests. Eligible participants had to exhibit shoulder pain for more than three months and a Body Mass Index (BMI) within the normal

range of 18.5-24.9 kg/m². To confirm the diagnosis of CRCT, participants were required to show at least four positive results out of the following six commonly used tests: Neer Test, Hawkins–Kennedy Test, Empty Can Test, External Rotation Resistance Test, Drop Arm Test, and Lift off Test)9).

Exclusion Criteria

Exclusion criteria included a history of shoulder surgery or any other surgical intervention to the shoulder joint, the presence of other shoulder pathologies such as adhesive capsulitis or significant Glenohumeral arthritis, and neurological deficits or movement disorders affecting the upper limb. Patients with contraindications to electro-acupuncture, such as those with pacemakers or severe varicose veins, were also excluded from the study.

Instrumentations

Instrumentations for Measurements

Health weight scale for weight and height measurements: was used to calculate BMI. (BMI= weight (kg) / [height (m) 2]), (10). Visual analogue scale (VAS): a 10-cm line that represents a continuum between “no pain” and “worst pain” was used for pain intensity level measurements (11). Smartphone Clinometer Application (Plain code Software Solutions, Gunzenhausen, Germany) was used to measure shoulder abduction, internal and external rotation (ROM), (12). The Arabic of version of The Disabilities of the Arm, Shoulder and Hand questionnaire: 30- item physical function questionnaire was used to assess disability level in patients with CRCT (13).

Instruments for Treatment

Elastic bands :(theraband, UK) for resistance. Acupuncture needles for acupoint insertion. Electronic acupuncture treatment instrument (MODEL NO. SDZ-III, china) produces low voltage microcurrent ranging from 10 μA to less than 10 mA and adjustable low frequency pulse ranging from 1 to 100 Hz to stimulate the acupuncture points **(Figure 1).**

Figure 1. Electronic acupuncture treatment instrument

Procedures for Measurements

Measurements were conducted for each participant prior to and following to the treatment period of time.

Measurement of Pain Intensity Level

The VAS is self-completed by the participant. The participant is asked to place a line perpendicular to the VAS 10 cm line at the point that represents their pain intensity. Using a ruler, the score is determined by measuring the distance (mm) on the 10-cm line between the “no pain” anchor and the patient’s mark, providing a range of scores from 0 –100 **(14).**

Measurement of Shoulder abduction, internal rotation and external rotation ROM

Smartphone clinometer application was used in measurement of shoulder abduction while participant in standing. The measurement of shoulder internal rotation and external rotation done while participant in supine with the arm abducted at 90 degree and elbow flexed at 90 degrees **(12).**

The DASH-Arabic questionnaire assesses shoulder, arm, and hand disabilities with 30 items on functional challenges, pain, and social impacts, plus optional modules for sports and work tasks. Scores range from 0 to 100, with higher scores indicating greater disability. Measurements were recorded before and after the six-week treatment to evaluate progress **(13).**

Procedures for treatment

Control group

The control group received a conventional physical therapy program focusing on scapular

and shoulder exercises to strengthen the serratus anterior, trapezius, and Glenohumeral muscles **(8).** Serratus anterior exercises began with wall push-ups with scapular protraction, progressing to inclined and horizontal push-ups as participants could complete three sets of ten repetitions without pain **(Figure 2).**

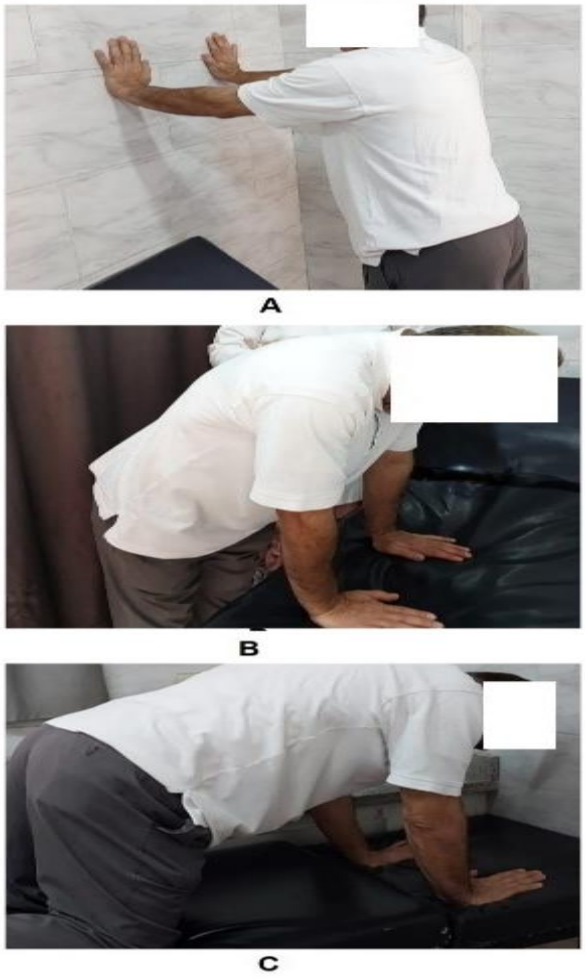

Figure 2. A: wall push-ups with press-outs (addition of scapular protraction). B: inclined push-ups with press-outs. C: horizontal push-ups with press-outs.

Trapezius exercises involved scapular retraction, starting with shoulders abducted to 45°, then 90° with elbows flexed, and finally in a prone position **(Figure 3).**

Figure 3. A: Trapezius strengthening exercises with shoulder abducted to 45° in a standing position. B: Trapezius strengthening exercises with shoulder abducted to 90° and elbow flexed to 90° while standing. C: Trapezius strengthening exercises with shoulder abducted to 90° and elbow flexed to 90° in prone position.

Glenohumeral exercises included resistive external and internal rotations with an elastic band, progressing from the arm beside the trunk to 30° abductions with elbow support **(Figure 4) (Figure 5)** And then to the resistive shoulder flexion and abduction exercises **(Figure 6).**

Figure 4. A: resistive shoulder external rotation exercise by elastic band from sitting with arm beside trunk. B: resistive shoulder internal rotation exercise by elastic band from sitting with arm beside trunk.

Figure 5. A: resistive shoulder external rotation exercise by elastic band from sitting with 30 degree of shoulder abduction and elbow supported on table. B: resistive shoulder internal rotation exercise by elastic band from sitting with 30 degree of shoulder abduction and elbow supported on table.

Figure 6. A: resistive shoulder flexion exercise by elastic band from standing position. B: resistive shoulder abduction exercise by elastic band from standing position.

All exercises followed the same parameters: three sets of ten repetitions, each held for six seconds, with two-minute rest intervals. The program consisted of one session daily for six weeks, including two supervised sessions weekly and a home program Experimental group m for the remaining days **(15).**

The Experimental group participants received both conventional physical therapy program and EA intervention using the Electronic Acupuncture Instrument SDZ-III **(Figure 1).** Under a certified TCM practitioner's guidance, acupuncture was administered At LI-15, TB-14, SI-10, and SI-13 points **(16).** The skin was sterilized with alcohol. Needles were inserted at specific depths for each point: LI-15 (1–1.5 cun), TB-14 (0.5–1 cun), SI-10 (0.5–1 cun), and SI-13 (0.5–1 cun). Electrodes were then attached to the needles, delivering a low-voltage intermittent microcurrent at 10 Hz for 25 minutes **(Figure 7).** The EA sessions were conducted twice a week for six weeks **(17).**

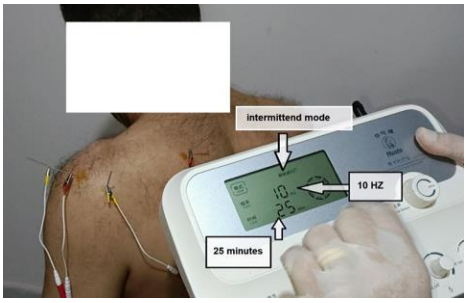

Figure 7. The parameters of the EA intervention

Data Collection

Data were screened for normality and homogeneity of variance. The Shapiro-Wilk test was used to assess normality, indicating that the data were normally distributed ($P > 0.05$) after removing outliers detected by box and whiskers plots. Additionally, Levene's test confirmed homogeneity of variance, showing no significant differences ($P > 0.05$). These results justified the use of both parametric and non-parametric analyses.

Statistical Analysis

Statistical analysis was performed using SPSS version 25 for Windows (SPSS, Inc., Chicago, IL). Quantitative data (e.g., VAS scores, abduction ROM, internal and external rotation ROM, DASH score) were expressed as mean ± standard deviation, while qualitative data (e.g., gender) were expressed as frequency (percentage). An independent t-test was used to compare demographic variables (age, weight, height, BMI) between the two groups. A chi-square test was conducted to compare gender differences within and between groups. Multivariate Analysis of Variance (MANOVA) was used to analyze the main dependent variables

(VAS, ROM and DASH) across different groups and measuring periods. A 2x2 mixed MANOVA design was employed, with the first independent variable being the groups (experimental vs. control) and the second Being the measuring periods (before vs. after treatment). Bonferroni correction (post hoc tests) was applied for pairwise comparisons where the MANOVA results were significant. A significance level of $P \leq 0.05$ was used for all statistical analyses.

Results

Clinical Characteristics of Subjects

A total of 66 patients were randomly assigned to either a control group (n=33), which received conventional physical therapy program, or an experimental group (n=33), which received the same conventional physical therapy program in addition to EA. The clinical characteristics of the 66 CRCT patients are summarized in **(Table 1).** The mean values for age, weight, height, and BMI were comparable between the experimental and control groups, with no statistically significant differences ($P > 0.05$). Specifically, the mean age was 34.97 ± 3.13 years for the experimental group and 34.85 ± 3.79 years for the control group. Mean weight was 72.00 ± 5.19 kg for the experimental group and 72.58 ± 5.54 kg for the control group. Similarly, mean height and BMI were also comparable between groups. According to the Shapiro-Wilk test, the data revealed a normal distribution for these variables.

Gender distribution across the two groups was also analyzed and found to be statistically non-significant ($P = 0.806$), as shown in **(Table 2).** The distribution of males and females was nearly identical between the experimental and control groups.

Mixed Design (2×2) Multivariate Analysis of Variance (MANOVA)

To analyze the effects of the treatment, a mixed ANOVA design was used to assess the main outcomes, including VAS scores, ROM (abduction, internal rotation, external rotation), and DASH scores. The results demonstrated a significant interaction effect between groups and time ($F = 175.690$, $P = 0.0001$), as well as significant effects for both groups and time individually ($P = 0.0001$) **(Table 3).**

Outcome Measures

VAS Scores: Within-group analysis indicated a significant reduction in VAS scores after treatment in both the experimental and control groups ($P < 0.05$). The reduction was more pronounced in the experimental group, with a mean change of 4.42 (72.58% improvement) compared to 1.70 (28.33% improvement) in the control group. This difference is illustrated in **(Table 4).**

ROM (Abduction, Internal Rotation, and External Rotation): The ROM for abduction, internal rotation, and external rotation significantly increased within both groups after treatment ($P < 0.05$). However, the experimental group demonstrated a significantly higher improvement percentage compared to the control group. For abduction ROM, the experimental group showed an 80.94% improvement versus 14.98% in the control group.

DASH Scores: DASH scores, which measure functional disability, also showed significant improvement in both groups post-treatment ($P < 0.05$). The reduction in DASH scores was greater in the experimental group (73.60% improvement) compared to the control group (10.05% improvement) **(Table 5).**

Table 1. Comparison of p mean values of participant's general characteristics between both groups

Items	Patients general characteristics			
	Age (Year)	**Weight (kg)**	**Height (cm)**	**BMI (kg/m2)**
Experimental group (n=33)	34.97 ±3.13	72.00 ±5.19	174.45 ±8.15	23.73 ±1.97
Control group (n=33)	34.85 ±3.79	72.58 ±5.54	175.00 ±9.98	23.85 ±2.66
t-value	0.141	0.435	0.243	0.209
P-value	0.888	0.665	0.809	0.835
Significance	NS	NS	NS	NS

Data are expressed as mean ±standard deviation (SD). P-value: probability value. NS: non-significan

Table 2. The gender distribution among groups

Items	Gender	
	Males	Females
Experimental group (n=33)	16 (48.50%)	17 (51.50%)
Control group (n=33)	17 (51.50%)	16 (48.50%)
Chi-square value	0.061	
P-value	0.806	
Significance	NS	

Data are expressed as frequency (percentage) P-value: probability value NS: non-significant

Table 3. Mixed design MANOVA for all dependent variables

Source of variation	Wilks' Lambda value	Eta2 (η2)	F-value	P-value	Significant
Tested groups effect	0.094	0.906	238.312	0.0001*	S
Training periods effect	0.132	0.868	163.206	0.0001*	S
Interaction effect	0.124	0.876	175.690	0.0001*	S

P-value: probability value S: significant * Significant (P<0.05

Table 4. Mixed MANOVA for the effect of treatment on VAS

VAS (Mean ±SD)				
Items	**Experimental group (n=33)**		**Control group (n=33)**	
Before-treatment	6.09 ±1.72		6.00 ±1.69	
After-treatment	1.67 ±1.40		4.30 ±1.75	
Mixed MANOVA (Overall effect)				
MANOVA Overall effect	**Eta2 (η2)**	**F-value**	**P-value**	**Significance**
Group effect	0.133	19.603	0.0001*	S
Time effect	0.470	113.364	0.0001*	S
Interaction (Group x Time) effect	0.150	22.504	0.0001*	S
Comparison between before- and after-treatment within each group (time effect)				
Time effect	**Experimental group**		**Control group**	
Mean difference (change)	4.42		1.70	
Improvement %	72.58%		28.33%	
95% CI	3.62 – 5.22		0.89 – 2.50	
F-value	118.443		17.425	
P-value	0.0001*		0.0001*	
Significance	S		S	
Comparison between both groups at before- and after-treatment (group effect)				
Group effect	**Before-treatment**		**After-treatment**	
Mean difference (change)	0.09		2.63	
95% CI	-0.71 – 0.89		1.83 – 3.44	
F-value	0.050		42.057	
P-value	0.823		0.0001*	
Significance	NS		S	

Data are expressed as mean ±standard deviation CI: confidence interval
P-value: probability value S: significant * Significant (P<0.05) NS: non-significant

Table 5. Mixed MANOVA for the effect of treatment on DASH score

DASH score (Mean ±SD)				
Items	**Experimental group (n=33)**		**Control group (n=33)**	
Before-treatment	57.27 ±12.09		56.12 ±9.64	
After-treatment	15.12 ±7.20		50.48 ±10.12	
Mixed MANOVA (Overall effect)				
MANOVA Overall effect	**Eta2 (η2)**	**F-value**	**P-value**	**Significance**
Group effect	0.466	111.803	0.0001*	S
Time effect	0.599	191.488	0.0001*	S
Interaction (Group x Time) effect	0.434	98.145	0.0001*	S
Comparison between before- and after-treatment within each group (time effect)				
Time effect	**Experimental group**		**Control group**	
Mean difference (change)	42.15		5.64	
Improvement %	73.60%		10.05%	
95% CI	37.32 – 46.98		0.80 – 10.46	
F-value	297.963		5.328	
P-value	0.0001*		0.023*	
Significance	S		S	
Comparison between both groups at before- and after-treatment (group effect)				
Group effect	**Before-treatment**		**After-treatment**	
Mean difference (change)	1.15		35.36	
95% CI	-3.68 – 5.98		30.53 – 40.19	
F-value	0.222		209.725	
P-value	0.638		0.0001*	
Significance	NS		S	

Data are expressed as mean ±standard deviation CI: confidence interval
P-value: probability value S: significant * Significant (P<0.05) NS: non-significant

Discussion:

The purpose of the current study was to examine the effect of EA on pain intensity level, shoulder abduction, internal and external rotation ROM, and functional disability level in patients with CRCT. The study demonstrated significant improvements in all these variables, including reduced pain intensity level, increased shoulder abduction, enhanced internal and external rotation ROM, and decreased functional disability level in the experimental group compared to the control group, which only received conventional physical therapy. These findings align with the references provided **(4,6,7,18)**, supporting the efficacy of EA as an adjunctive therapy for managing CRCT.

Conclusion:

In conclusion, this study demonstrates that EA is an effective intervention for reducing pain, improving shoulder abduction, internal rotation and external rotation ROM, and decreasing functional disabilities level in patients with CRCT. The integration of EA with conventional therapy offers a comprehensive approach to managing this chronic condition. The findings

contribute to the growing body of evidence supporting the use of EA in musculoskeletal disorders and highlight the need for further research to optimize its clinical application.

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