

# Efficacy observation and prognostic analysis of sling exercise therapy combined with warm acupuncture moxibustion in the treatment of patients with rotator cuff injuries: A 6-week randomized controlled trial

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**Abstract:** Objective: To evaluate the clinical efficacy, advantage and continuity of rotator cuff elasticity and shoulder joint function of sling exercise therapy(-SET) combined with warm acupuncture moxibustion in the treatment of patients with rotator cuff injuries(RCI) using shear wave elastography(SWE).

Method: Collecting patients who attended the outpatient clinic of the Department of Acupuncture and Rehabilitation of Hangzhou Hospital of Traditional Chinese Medicine from March 2022 to March 2023. Sixty patients with rotator cuff injuries were randomly divided into 30 cases each in the treatment group and the control group. In the control group, 1 case was dislodged due to traveling in the middle of the day, totaling 59 cases. Both groups were intervened with basic treatment of joint loosening. The control group was given warm acupuncture moxibustion(WAM) treatment, and the treatment group was combined with SET suspension training on the basis of the control group for 6 weeks. Visual analog score (VAS), shoulder joint active range of motion (SAROM), Young's modulus (E) and rotator cuff quality of life index (RC-QOL) were used to evaluate the pain intensity, shoulder mobility, rotator cuff muscle and tendon elasticity, and quality of life of the patients before and after the treatment, and to compare the clinical efficacy of the two groups. The VAS was evaluated again at the end of the treatment for a follow-up of 3 months to observe the stability of the treatment effect.

Results: VAS and E decreased and SAROM and RC-QOL increased in both groups after treatment compared with before treatment, and the differences were statistically significant ( $P<0.05$ ). At the end of treatment, there were significant decreased in VAS and E increases in outreach SAROM and RC-QOL in the treatment group compared with the control group, and the differences between the two groups were statistically significant ( $P<0.05$ ). In the treatment group, the range of adduction, internal rotation and external rotation SAROM was expanded, but the differences were not statistically significant compared with the control group ( $P>0.05$ ). The clinical effective rate was 96.67% in the treatment group and 79.67% in the control group, and the difference was statistically different ( $P<0.05$ ). At the follow-up 3 months after the end of treatment, the VAS of the treatment group was lower than the same group at the end of treatment. It was also lower

than the control group. The differences were statistically significant ( $P < 0.05$ ). In contrast, the VAS of the control group did not see any significant changes compared with the same group, and the differences were not statistically significant ( $P > 0.05$ ).

Conclusions: SET combined with WAM can effectively relieve pain, improve shoulder joint function, rotator cuff elasticity, and enhance the quality of life of patients with RCI. Compared with the treatment of WAM alone, the effect of the intervention of SET is more stable and long-lasting in terms of pain relief.

**Keywords:** Rotator cuff injury; Warm acupuncture moxibustion; Sling exercise therapy; Shear wave elastography; Young's modulus

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## Introduction

Rotator cuff injury (RCI) refers to hemorrhagic edema, tendinitis and fibrosis of the rotator cuff (including supraspinatus, infraspinatus, teres minor, and subscapularis) due to various reasons, or even one or more of them are torn, which triggers localized pain or dysfunction of the shoulder joint<sup>[1-2]</sup>. The disease is common in elderly patients<sup>[3]</sup>, but with the development of national fitness campaigns and repeated over-the-top movements in people's daily lives and work, the incidence of the disease has risen in the young-adult population<sup>[4]</sup>. In clinical practice, treatments include non-surgical and surgical treatments. The Guidelines for Integrating Traditional Chinese and Western Medicine in the Treatment of RCI (2023) state that warm acupuncture moxibustion (WAM) and manipulative therapy can effectively improve shoulder pain and shoulder function<sup>[5]</sup>. However, traditional manipulative rehabilitation training often causes pain that patients cannot adhere to, especially in the acute phase of the disease, and the use of this method may further deteriorate the condition. Therefore, it becomes crucial to find an exercise method that can effectively promote rehabilitation without causing pain.

Sling exercise training (SET) is a new type of rehabilitation treatment based on the latest modern rehabilitation theories<sup>[6]</sup>. SET is a comprehensive training system for sport sensation, emphasizing on the movement in unsteady state, and improving the body's balance, control, and stability in movement<sup>[7]</sup>. SET enables to guide the patients to perform the functional training of open-chain or closed-chain, to improve the mobility of the joints and the control of the movement without pain. It also improves joint stability and patients' partial proprioception<sup>[8]</sup>. For RCI, WAM is also effective<sup>[9]</sup>. In this study, WAM and SET were combined to treat RCI, and shear wave elastography (SWE) was used as an assessment tool to prove the clinical efficacy of this treatment through objective data, to popularize it in the clinic, and it is reported as follows.

## Materials and methods

Clinical data: From March 2022 to March 2023, patients diagnosed with

RCI in the outpatient Department of Acupuncture and Rehabilitation of Hangzhou Hospital of Traditional Chinese Medicine (including Wulin and Dingqiao Campus) were collected. This study was reviewed and approved by the Research Ethics Committee of Hangzhou Hospital of Traditional Chinese Medicine (2022KY004). All subjects signed the informed consent.

Standard of diagnosis<sup>[7]</sup>: (1) Patients with a clear history of shoulder trauma, or with a long course of disease or without an obvious history of shoulder trauma; (2) Shoulder pain: it was intermittent in the early stage, and the pain is obvious when working or lying on the side of pressure. The pain is generally located in the anterolateral shoulder and deltoid muscle, which could be relieved after rest. If combined with chronic subacromial bursitis, the pain is often persistent or refractory. (3) Shoulder joint dysfunction: unable to abduct or weak abduction and lifting. In severe cases, the shoulder is unstable. (4) Muscle atrophy: atrophy of the supraspinatus, infraspinatus and deltoid muscles occurred with a long course of the disease, accompanied by a grating sound during movement or palpation. (5) Pain arc sign is positive. When the affected arm was raised 60°-120°, it was occurred pain in the anterior or inferior region of shoulder; (6) Positive impact test: when the acromion was compressed downward and the affected arm was lifted passively, such as pain under the acromion or accompanied by difficulty in lifting, it was positive; (7) Imaging evidence: MRI showed that the signal intensity of the tendon increased locally, but the continuity still existed or partially disappeared, and there was effusion in the subacromial bursa. Anyone with item (7) and one or several other items combined at the same time can be diagnosed as RCI.

Inclusion criteria: (1) Meet the above diagnostic criteria; (2) Males and females between the ages of 18 and 70; (3) Patients who did not use other treatment methods within 1 week before inclusion; (4) All included subjects shall obtain relevant informed consent and sign consent voluntarily.

Exclusion criteria: (1) Patients with severe osteoporosis, glenohumeral degeneration and SLAP injury; (2) Combined with brachial plexus, axillary nerve injury and suprascapular nerve entrapment, affecting the pain evaluation; (3) Patients who have not removed the stitches after rotator cuff repair and those who have poorly healed surgical incisions; (4) Shoulder joint local skin infection or rupture; (5) Poor compliance, volunteer to quit clinical researchers.

Culling and shedding criteria: (1) The number of treatments cannot be completed at least 50% of the cases as required; (2) The researcher believes that the subject of the study is no longer suitable for further research, e.g. subjects with sudden serious illness, such as renal disease, pneumonia and other illness; (3) If the researcher considers that the patient's compliance is poor and it is inappropriate to carry out the study. The subjects no longer cooperates with the researcher's arrangement for personal reasons

Research method: Through the random assignment macro procedure, patients were randomly assigned to the control group or the treatment group ac-

according to the order of visits, with 30 people in each group. In the control group, 1 case fell off due to a business trip. Finally, 59 cases were included.

Therapeutic schedule: Both the control group(C) and the treatment group(T) underwent joint mobilization as the basic treatment. On this basis, the control group was treated with WAM, and the treatment group was treated with WAM combined with SET. The treatment time of the two groups was 6 weeks. Specific treatments are as follows.

Joint mobilization: ① Loosening shoulder blades: The patient lies on the healthy side, the therapist places one hand on the shoulder peak of the patient, and the forehead of the other hand is placed on the lower corner of the medial edge of the scapula. Performing the movements of anterior extension of the scapula, posterior retraction, lifting up, lowering down, upward rotation, and downward rotation, etc. Each movement is performed 5 times, each time for about 6s of continuous stretching. ② Static joint loosening: The glenohumeral joint is separated by traction, sliding to the head end, sliding to the tail end, sliding forward and backward. Forward sliding of the acromioclavicular joint. The sternoclavicular joint slides backward, forward, downward and downward. Each movement is performed 5 times, each time for about 6s of continuous stretching. ③ Dynamic joint loosening: Loosening glenohumeral joints, acromioclavicular joints, sternoclavicular joints, and shoulder strap muscles.

All of the above maneuvers were evaluated by a rehabilitation therapist for muscle damage. The intensity and range of motion were performed within the patient's tolerance range to prevent secondary injury during treatment. The above training were 20 minutes each time, 3 times a week (Monday, Wednesday and Friday), and a total of 18 treatments were performed in 6 weeks.

WAM: ① Acupuncture points: Jianliao(SJ14), Jianyu(LI15), Binao(LI14), Jianzhen(SI9), Jianqian(EX-UE12), Quchi(LI11). ② Operational approach: Healthy lateral position, after routine disinfection of local acupuncture points skin, using 40×0.3mm millimeter needles (Jiachen brand acupuncture needle, Wujiang city, Jiachen Acupuncture and Moxibustion Equipment Co., Ltd.). After entering the needle, lift and insert, twist and turn flat supplement and flat drainage technique, acupuncture becomes needling sensation(it means deqi), and the needle feeling is acid, numbness, distension and heaviness (can be combined or single). Then, use a strong piece of moxa to ignite one end close to the skin and insert it into each needle handle. The length of the piece of moxa is about 2-3cm from the skin, prepared with a thick piece of paper. When the patient needles local burning pain during WAM, a thick piece of paper can be used to separate the part close to the skin. After two strong pieces of moxa, flick the moxa ash and take out the needle. Keep the needle for 20-30min each time, 3 times a week, with an intervention of 6 weeks.

SET: ① The patient is lying on the healthy side, with the head resting on the arm or balance cushion and the shoulder joint suspended axially. Narrow straps were placed at the elbow joint and the rope was elevated to move the arm slightly

away from the body. Anterior flexion exercises are performed with elastic bands after distal upper extremity support is given to activate the scapular stabilizing muscle groups such as the serratus anterior and the middle and lower trapezius muscles. ② The patient is placed in the supine position with the shoulder perpendicular to the suspension belt, the arms are placed flat on both sides of the body, and the suspension belt is at the distal end of the upper limb. The shoulder joints are lightly flexed and the center divided band is secured to the back using an elastic cord strap. The wide band is fixed to the pelvis using an elastic cord strap, and the roller is placed below the knee joint. Train shoulder abduction and other movements as much as possible in a pain-free state to fully stimulate the shoulder muscles. ③ The patient kneels to train anterior shoulder extension, grasping the sling with both hands, with the sling height at wrist level. Keeping the body straight, the body is leaned forward until the shoulder joint is flexed anteriorly at 90°. The sling is at waist level, the chest can be given a wide band elastic cord for weight reduction, and the affected limb is pushed forward to bring the scapula forward.

The movement difficulty of ① ~ ③ is gradually increasing, and the patient mainly takes ① ② movements in the early stage. If the patient's pain and mobility improve well, the patient can gradually take ② ③ movements to prevent secondary injuries during treatment. The above actions are 1 set, and do 3 sets of training each time. According to the actual situation of the patient, the rehabilitation therapist adjusted the training time of 30min, 5 times a week, a total of 6 weeks.

Observational index: (1) Pain intensity: The visual analogue scale(VAS)<sup>[10]</sup> is adopted. A ruler of about 10cm in length with 10 scales engraved on one side and "0" and "10" at each end. "0" means painless, and "10" means severe pain. As the score increases, so does the intensity of the pain. This was used to evaluate shoulder and lateral upper arm pain and radial pain in the upper extremity.

Shoulder joint mobility function: Shoulder Joint Active Range of Motion (SAROM) is measured in four directions: abduction (supraspinatus), internal rotation (subscapularis), external rotation (infraspinatus, teres minor), and internal retraction (subscapularis). Measurement method: ① Abduction: The patient is seated with the arm relaxed downward, thumb forward and palm toward the axillary side. Consider the acromion as the "0" point and fix the "0" of the protractor on the acromion during the measurement. Ensure that the fixed arm of the protractor is parallel to the midline and that the mobile arm is parallel to the long axis of the humerus. Active abduction is performed to the limit and the angle is measured as the degree of abduction. ② Adduction: Patient in sitting position, shoulder abduction 90°, palm down. The fixed arm is perpendicular to the sagittal plane through the acromion. Mobile arm: long axis of the humerus, fix the "0" of the protractor on the acromion. Active internalization to the limit, measure its angle, that is, the degree of internalization activity. ③ Internal rotation: The patient is seated with the forearm in neutral position and the elbow flexed to 90°. Fixed

arm: ulnar humerus perpendicular to the coronal plane. Mobile arm: long axis of the ulna. Fix the “0” of the protractor on the ulnar humerus. Active internal rotation to the limit, measure its angle, that is, the degree of internal rotation activity.

④ External rotation: Patient seated, forearm in neutral position, elbow flexed to 90°. Fixed arm: ulnar humerus perpendicular to the coronal plane. Mobile arm: long axis of the ulna. Fix the “0” of the protractor on the ulnar humerus. Active external rotation to the limit, and measure the angle as the degree of external rotation activity.

Rotator cuff muscle tendon elasticity: Young’s modulus (E) was used to evaluate rotator cuff tendon hardness. The larger the E, the less elastic, the smaller the E, the more elastic. Body position: The patient was placed in the modified Grass position. The probe is placed lightly on the client’s shoulder and the hand is not pressed as much as possible to eliminate the influence of external force on the local muscle compression of the rotator cuff. The elastic range was set at 800kpa. The probe was consistent with the shape of the muscle tendon fibers. The plane of the acoustic beam was perpendicular to the surface of the tendons, and the anisotropic artifacts of the tendons were discharged to clearly show the rotator cuff muscle tendon fibers. The size of the sampling frame was set as 2\*1cm, and the location was selected to be 1.5cm away from the attachment point of the injured muscle tendon. The E value is measured here

Quality of life in patients with rotator cuff injury: The Rotator Cuff Quality-of-Life Measure (RC-QOL)<sup>[11]</sup> was utilized to assess the quality of life of patients. This scoring system consists of five sections, including physical-related symptoms (with 16 questions), occupational-related symptoms (with 4 questions), motor-related symptoms (with 4 questions), daily living-related symptoms (with 5 questions), and socio-emotional-related symptoms (with 5 questions). There are in total 34 questions, and each question is scored between 0-100 by selecting the appropriate degree. 0 means extremely intense and 100 means not at all. The system scored 3400 points totally.

Clinical efficacy<sup>[12]</sup>: Cured: Shoulder pain and tenderness disappear, shoulder joint function recovery. Improved: Reduced shoulder pain and improved function. Ineffective: Symptoms do not improve.

Follow-up: Patients in both groups were followed up 3 months after the end of treatment, and the VAS index was evaluated again at this time to observe the stability of the treatment effect of SET suspension training.

Statistical method: SPSS17.0 statistical software was used for statistical analysis. Qualitative data were obtained by chi-square test. Measurement data conforming to normal distribution are represented by mean  $\pm$  standard deviation. If variance is homogeneous, paired sample t test is used for intra-group comparison, and two independent samples t test is used for inter-group comparison. If the variance is not uniform, the rank sum test is used.  $P < 0.05$  was considered statistically significant.

## Results

### Baseline data

There was no significant difference in gender, age, disease duration, site of rotator cuff injury, VAS before treatment, SAROM before treatment, E value and RC-QOL before treatment between the two groups ( $P>0.05$ ). The baseline data were comparable, and the details are shown in **Table 1**.

**Table 1.** Baseline data before treatment in both groups

| Variable               | T(N=30)        | C(N=29)        | $t/\chi^2$ | P     |
|------------------------|----------------|----------------|------------|-------|
| Age(year)              | 53.50±13.66    | 51.21±11.97    | 0.847      | 0.496 |
| Course of disease(day) | 124.30±39.71   | 171.10±43.39   | -0.797     | 0.429 |
| Sex                    |                |                | 3.114      | 0.078 |
| male                   | 15             | 8              |            |       |
| female                 | 15             | 21             |            |       |
| Injured part           |                |                | 2.076      | 0.15  |
| Left                   | 17             | 11             |            |       |
| Right                  | 13             | 18             |            |       |
| VAS(score)             | 4.77±1.43      | 4.59±1.18      | 0.527      | 0.6   |
| SAROM(degree)          |                |                |            |       |
| Outreach               | 111.00±16.99   | 106.90±22.14   | 0.8        | 0.427 |
| Adduction              | 36.83±8.25     | 35.86±8.25     | 0.452      | 0.653 |
| Internal rotation      | 55.17±19.93    | 57.24±22.50    | -0.375     | 0.709 |
| External rotation      | 62.50±27.79    | 58.97±26.30    | 0.501      | 0.618 |
| E(Pa)                  |                |                |            |       |
| Side of the disease    | 109.41±12.11   | 104.08±15.50   | 1.477      | 0.145 |
| Side of the health     | 62.50±27.79    | 58.97±26.30    | 1.948      | 0.056 |
| RC-QOL(score)          | 1343.30±318.56 | 1386.28±346.23 | -0.496     | 0.622 |

### VAS scores before and after treatment in both groups

As shown in **Table 2**, the VAS scores of the treatment group after treatment were significantly different from those before treatment ( $t=10.105$ ,  $P<0.05$ ). The VAS scores of the control group after treatment were significantly different from those before treatment ( $t=6.817$ ,  $P<0.05$ ). After treatment, the score of the treatment group ( $1.97\pm1.16$ ) was significantly lower than that of the control group ( $3.24\pm1.12$ ), and the difference was statistically significant ( $t=-4.288$ ,  $P<0.05$ ).

As shown in **Table 3**, there was a significant difference between the treatment group after 3 months of follow-up and after treatment ( $t=5.188$ ,  $P<0.05$ ). In the control group, the difference was statistically significant after 3 months of follow-up ( $t=-0.722$ ,  $P<0.05$ ). After 3 months of follow-up, the treatment group

was significantly lower than the control group ( $t=-7.709$ ,  $P<0.05$ ).

**Table2.** VAS scores before and after treatment in two groups( $\bar{x} \pm s$ , score)

| Group | Number of cases | Before the treatment | After the treatment | t      | P      |
|-------|-----------------|----------------------|---------------------|--------|--------|
| T     | 30              | 4.77±1.43            | 1.97±1.16*#         | 10.105 | <0.001 |
| C     | 29              | 4.59±1.18            | 3.24±1.12*          | 6.817  | <0.001 |

Note: \* The difference was statistically significant compared with that before treatment. # Compared with the control group, the difference was statistically significant.

**Table 3.** VAS scores after treatment and 3 months after treatment in two groups( $\bar{x} \pm s$ , score)

| Group | Number of cases | After the treatment | Follow-up 3 months | t      | P      |
|-------|-----------------|---------------------|--------------------|--------|--------|
| T     | 30              | 1.97±1.16           | 1.33±1.06*#        | 5.188  | <0.001 |
| C     | 29              | 3.24±1.12           | 3.37±0.93*         | -0.722 | 0.477  |

Note: \* The difference was statistically significant compared with that before treatment. # Compared with the control group, the difference was statistically significant.

### SAROM before and after treatment in both groups

As shown in **Table 4**, there were significant differences in SAROM(abduction, adduction, internal rotation, external rotation) between the two groups after treatment and before treatment ( $P<0.05$ ). After treatment, the abduction range of SAROM in the treatment group ( $133.67\pm16.91^\circ$ ) was larger than that in the control group ( $121.21\pm20.34^\circ$ ), and the difference was statistically significant ( $t=0.013$ ,  $P<0.05$ ). There was no significant difference in the other SAROM(adduction, internal rotation, external rotation) between the treatment group and the control group ( $P>0.05$ ).

**Table4.** SAROM before and after treatment in both groups( $\bar{x} \pm s$ , degree)

| Group | Time                 | Number of cases | Outreach       | Adduction   | Internal rotation | External rotation |
|-------|----------------------|-----------------|----------------|-------------|-------------------|-------------------|
| T     | Before the treatment | 30              | 111.00±16.99   | 36.83±8.25  | 55.17±19.93       | 62.50±27.79       |
|       | After the treatment  | 29              | 133.67±16.91*# | 40.67±7.51* | 61.17±17.50*      | 68.67±25.19*      |
| C     | Before the treatment | 30              | 106.90±22.14   | 35.86±8.25  | 57.24±22.50       | 58.97±26.30       |
|       | After the treatment  | 29              | 121.21±20.34*  | 41.03±5.57* | 60.52±22.01*      | 63.28±24.29*      |
| t(T)  | /                    | /               | -9.421         | -4.173      | -5.174            | -5.524            |
| P(T)  | /                    | /               | <0.001         | <0.001      | <0.001            | <0.001            |
| t(C)  | /                    | /               | -6.857         | -4.129      | -4.335            | -3.299            |
| P(C)  | /                    | /               | <0.001         | <0.001      | <0.001            | <0.001            |

Note: \* The difference was statistically significant compared with that before treatment. # Compared with the control group, the difference was statistically significant.

### E value before and after treatment in both groups

**Table 5** shows that the E values of the healthy side and the diseased side of

the two groups after treatment were compared with those before treatment, the differences were statistically significant ( $P < 0.05$ ). After treatment, the E value of the diseased side in the treatment group ( $94.05 \pm 11.20$ )Pa was significantly lower than that in the control group ( $101.54 \pm 15.68$ )Pa, and the difference was statistically significant ( $t = 0.039$ ,  $P < 0.05$ ). There was no significant difference in the E value of the healthy side between the two groups ( $P > 0.05$ ). Figure 1 shows the SWE of shoulder joint of a patient before and after treatment. Comparison of the two figures shows that the yellow area before treatment is larger and darker than that after treatment, indicating that the elasticity of muscle and tendon is significantly improved after treatment.

**Table 5.** E before and after treatment in both groups ( $\bar{x} \pm s$ , Pa)

| Group | Time                 | Number of cases | Side of the disease      | Side of the health    |
|-------|----------------------|-----------------|--------------------------|-----------------------|
| T     | Before the treatment | 30              | $109.41 \pm 12.11$       | $62.50 \pm 27.79$     |
|       | After the treatment  | 29              | $94.05 \pm 11.20^{* \#}$ | $68.67 \pm 25.19^{*}$ |
| C     | Before the treatment | 30              | $104.08 \pm 15.50$       | $58.97 \pm 26.30$     |
|       | After the treatment  | 29              | $101.54 \pm 15.68^{*}$   | $63.28 \pm 24.29^{*}$ |
| t(T)  | /                    | /               | 9.743                    | 3.218                 |
| P(T)  | /                    | /               | <0.001                   | <0.003                |
| t(C)  | /                    | /               | 6.89                     | 3.637                 |
| P(C)  | /                    | /               | <0.001                   | <0.001                |

Note: \* The difference was statistically significant compared with that before treatment. # Compared with the control group, the difference was statistically significant.

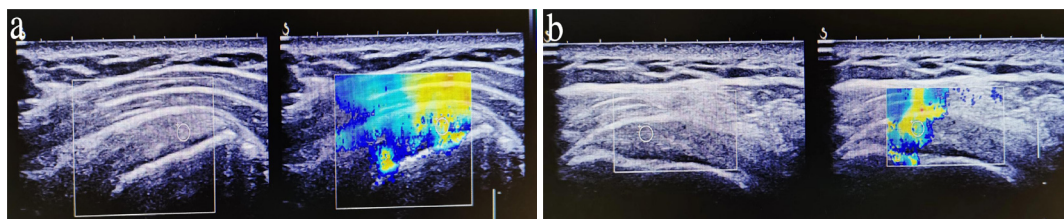


**Figure 1.** SWE of shoulder joint before the treatment(a) and after the treatment (b)

Note: The yellow area in (a) was more larger and darker than that in (b), and the E value decreased after treatment, indicating that the muscle tendon elasticity improved significantly after treatment.

### RC-QOL score before and after treatment in both groups

As shown in Table 6, after treatment the RC-QOL of the treatment group was significantly different from that before treatment ( $t = -16.534$ ,  $P < 0.05$ ). There were significant differences in RC-QOL between before and after treatment in the control group ( $t = -5.635$ ,  $P < 0.05$ ). After treatment, the RC-QOL score of the treatment group ( $2368.37 \pm 275.80$ ) was higher than that of the control group ( $1737.76 \pm 393.33$ ), and the difference was statistically significant ( $t = 7.11$ ,  $P < 0.05$ ).

**Table6.** RC-QOL before and after treatment in both groups( $\bar{x} \pm s$ , score)

| Group | Number of cases | Before the treatment | After the treatment | t       | P     |
|-------|-----------------|----------------------|---------------------|---------|-------|
| T     | 30              | 1343.30±318.56       | 2368.37±275.80*#    | -16.534 | <0.05 |
| C     | 29              | 1386.28±346.23       | 1737.76±393.33      | -5.635  | <0.05 |

Note: \* The difference was statistically significant compared with that before treatment. # Compared with the control group, the difference was statistically significant.

### Evaluation of clinical efficacy after treatment in both groups

As shown in **Table 7**, in the treatment group, 12 cases were cured, 17 cases were improved, and 1 case was ineffective, with a total effective rate of 96.67%. In the control group, 5 cases were cured, 18 cases were improved, and 6 cases were ineffective, with a total effective rate of 79.31%. The difference between the two groups was statistically significant ( $\chi^2=7.11$ ,  $P<0.05$ ).

**Table6.** Curative effect between the two groups( $\bar{x} \pm s$ )

| Group | Number of cases | Cured | Improved | Ineffective | Effective rate(%) | $\chi^2$ | P     |
|-------|-----------------|-------|----------|-------------|-------------------|----------|-------|
| T     | 30              | 12    | 17       | 1           | 96.67             | 7.608    | 0.022 |
| C     | 29              | 5     | 18       | 6           | 79.31             |          |       |

### Discussion

There are numerous evaluation methods for RCI. First of all, it is necessary to understand the patient's complaints to perform a physical examination, and some scales such as VAS, ROM, RC-QOL can be used to assess shoulder function and severity of the condition from the perspective of pain, mobility and quality of life<sup>[13-14]</sup>. Diagnosis usually needs to be supported by a combination of imaging, and the process involves a variety of aspects such as invasiveness, convenience, affordability and comfort. In view of the above problems, musculoskeletal ultrasound and MR of the shoulder joint are accepted by the majority of patients, and musculoskeletal ultrasound of the shoulder joint is easier to implement because of its low price and short time consuming. However, with VAS, SAROM and RCI-QOL assessment is slightly subjective, and musculoskeletal ultrasound and MR are not able to quantify the pain caused by RCI or the recovery of shoulder dysfunction in a more intuitive and concrete way. In recent years more and more researchers and clinicians have turned their attention to shear wave elastography (SWE)<sup>[15-16]</sup> and applied it to the assessment of skeletal muscle<sup>[17-18]</sup>, with the main observable index being Young's modulus. It can be measured directly by SWE and responds to muscle stiffness, with greater muscle stiffness indicating greater stiffness and its less elasticity<sup>[19]</sup>.

In this study, the E value of the healthy side and the affected side of the patient were compared, as well as the E value before and after treatment. Patients with damaged muscle tendons can experience muscle adhesion, spasm and con-

traction, pulling the fascia and forming reflex pain and pressure pain. Such pain signals can release analgesic substances, exacerbate soft tissue hypoxia and muscle spasms, cause localised muscle stiffness and muscle cord-like contractions, which in turn cause an increase in E value<sup>[20]</sup>. Acupuncture therapy can improve the local inflammatory response of muscles and tendons and relieve pain. Some studies have shown that acupuncture can significantly improve the stiffness of patients' muscles and reduce the E-value<sup>[21]</sup>. In this study, the E values of the healthy side and the affected side of the patients in both groups were measured, and the results showed that the E values of both sides of the patients in both groups decreased compared with the previous ones, and the difference was statistically significant ( $P < 0.05$ ). It indicates that the elasticity of the muscle tendons around the shoulder joint of the patients on both sides was improved compared with the previous one. The E value of the affected side of the treatment group was reduced more significantly compared with the E value of the affected side of the control group after treatment ( $P < 0.05$ ). This indicates that the treatment group has a more significant effect on improving the elasticity of the local muscles and tendons of the affected shoulder. It is verified that WAM combined with SET can reduce the muscle hardness of patients to restore muscle elasticity and further promote the recovery of their shoulder joint function.

The elasticity of the muscles and tendons around the shoulder joint on the healthy side also improved in the untreated group. This suggests that the improvement in the function of the shoulder joint on the affected side has a beneficial effect on the function of the shoulder joint on the healthy side. We speculate that this may be due to the fact that the patients can use their shoulder joints in a better way after treatment, and the elasticity of the muscles and tendons around the shoulder joints can be restored on both sides. However, the improvement is still limited, thus the difference between the treatment group and the control group after treatment of the healthy side is not statistically significant ( $P > 0.05$ ), which means that the difference between the two therapies in improving the elasticity of the muscles and tendons around the healthy shoulder joint is not significant.

Although the research value of SWE in skeletal muscle has been gradually and progressively valued by a wide range of scholars, its results are also affected by various aspects concerning muscle contraction status, size of tension, degree of spasm, tissue overlap, etc., so it can be used as a reference to a certain extent<sup>[22]</sup>. It is still necessary to refer to other indicators for comprehensive evaluation in outcome assessment to improve the accuracy. Thus, in this study, VAS, SAROM, RC-QOL and clinical efficacy were selected for assessment.

The results of this study showed that the VAS of the control group improved significantly after treatment compared with that before treatment ( $P < 0.05$ ), suggesting that simple WAM can effectively relieve shoulder pain. Modern medical research has also confirmed that the warm stimulation of warm needles travels along the body of the needle into the deep tissues. By up-regulating the expres-

sion of vascular endothelial growth factor, the enhancement of cells can enhance cell phagocytosis, produce strong anti-inflammatory effects around the relevant nerves, promote the absorption and metabolism of inflammatory exudates, reduce the excitability of the receptors of the nerve endings around the shoulder joint capsule, and play an anti-inflammatory and pain-relieving role[23-24]. The VAS of the treatment group improved significantly after treatment compared with that before treatment ( $P<0.05$ ), and the treatment group was better than the control group in terms of pain improvement at the end of treatment ( $P<0.05$ ). It is suggested that compared with WAM alone, the treatment of RCI combined with SET can be more effective in relieving rotator cuff-induced shoulder pain. Some patients with RCI injuries have pain that does not last forever and does not recur after treatment, but rather comes and goes. This is related to the issue of pain activation. It has been shown that maladaptation of muscle activation patterns is an important mechanism for pain<sup>[25]</sup>. The activation pattern that triggers pain is mainly a decrease in the level of deep muscle activation and an increase in the level of superficial muscle activity[26-27]. Therefore it is crucial to adjust the activation pattern of muscles utilizing intervention. It has been shown that regardless of the type of suspension, core stability training on the suspension rope can better activate the deep muscles to participate in the activity rather than the superficial muscles, so WAM combined with SET is more beneficial than WAM alone in relieving pain[28-29]. After 3 months of follow-up, the VAS of the treatment group also decreased significantly and gradually, suggesting that the treatment group was also better than the control group in the maintenance of the pain improvement effect ( $P<0.05$ ). After 3 months of follow-up, the VAS of the treatment group also decreased significantly and gradually, suggesting that the treatment group was also better than the control group in the maintenance of the pain improvement effect ( $P<0.05$ ). We speculate that this may be due to the fact that there is still a maintenance effect of pain improvement due to the good changes in the patients' muscle-tendon elasticity and shoulder joint movement patterns. It confirms the profound effect of SET on pain mechanisms after RCI.

In terms of SAROM, both groups showed significant improvement in the affected side's adduction, internal rotation, external rotation, and abduction SAROM after treatment compared to before ( $P<0.05$ ). However, comparing the two groups after treatment, the difference in the SAROM of the affected side of adduction, internal rotation and external rotation between the treatment group and the control group was not statistically significant ( $P>0.05$ ), while the improvement of abduction SAROM in the treatment group was more obvious than that in the control group ( $P<0.05$ ). We considered that within the normal range of mobility of all parties of the shoulder joint, adduction, internal rotation, and external rotation angles were all significantly smaller than the abduction angle. The latter is more likely to reflect the variability of changes than the previous three, so WAM combined with SET in this study only reflected a significant advantage over WAM alone in abduction SAROM. In this study, from the perspective of

improving shoulder joint dysfunction, the combination of SET on the basis of WAM and basic rehabilitation training. It is intended to perform closed-chain functional exercises mainly under painless conditions to increase joint mobility, enhance muscle movement control ability, and restore joint mobility to the normal range in a short period of time<sup>[30]</sup>. At the same time, the core stabilizing muscles were strengthened to increase joint mobility and form the correct muscle force generation and movement patterns<sup>[31]</sup>.

The RC-QOL index is used to assess the health status and quality of life of patients with a full range of RCI[32-33]. In this study, RC-QOL was used to assess patients' quality of life before and after treatment, which was significantly higher in both groups after treatment ( $P < 0.05$ ). RC-QOL was more significantly increased in the treatment group than in the control group after treatment, and the difference was statistically significant ( $P < 0.05$ ). RCI seriously affects work and daily life<sup>[34]</sup>. SET can relax muscles, improve muscle strength and endurance, activate stabilizing muscles, and increase sensory-motor control, and has been widely used for dysfunctions caused by various musculoskeletal disorders. In this study, the clinical effective rate of SET combined with WAM reached 96.67%, and the clinical effective rate of WAM alone was 79.31%, which was statistically significant ( $P < 0.05$ ). It suggests that the clinical efficacy of SET combined with WAM is better than that of WAM alone. A Meta-analysis demonstrated that acupuncture alone or combined with physiotherapy was effective for short- and medium-term functional improvement<sup>[35]</sup>. In the future, we need to expand the sample size and follow-up time to determine the long-term efficacy of SET combined with WAM.

Most of the current studies related to RCI generally focus on the improvement of shoulder function after treatment, and rarely involve the aspect of how to better maintain shoulder function after improvement. In this study, we investigated five aspects of pain, shoulder mobility, muscle and tendon elasticity, quality of life, and clinical efficacy of rotator cuff injuries by combining WAM and SET. From a certain point of view, it was confirmed that SET constructed a better movement pattern for the shoulder joint of patients with RCI. It helps to cultivate the patients to form a good shoulder joint use method in the future life, so as to prevent the occurrence of shoulder joint diseases. This study finally concluded that WAM combined with SET can effectively relieve shoulder joint pain, improve muscle and tendon elasticity, shoulder joint mobility, especially abduction mobility, and improve the quality of life of patients with RCI. It also achieved better maintenance efficacy in relieving pain and reduced the recurrence of RCI.

## Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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