# The efficacy of low-level laser therapy in supraspinatus tendinitis

**Liz Saunders** Physiotherapy Department, Derby City General Hospital, Derby

Twenty-four subjects were randomly assigned to two groups to assess the effectiveness of low-power laser therapy for supraspinatus tendinitis. A low-power laser using a 820 nm, 40 mW probe operating at 5000 Hz to produce a dose of 30 J/cm$^2$ was used to treat one group (L); the other group was treated with a similar, but dummy, laser (DL). The design of the trial was double-blind; patients, therapists and assessors being ignorant of the form of treatment used. The two groups each received a course of nine treatments and identical advice and educational material. Perceived pain was assessed and tenderness and secondary muscle weakness measured before and after the course of treatment.

The data revealed that the L group had less pain ($p < 0.05$), less secondary weakness ($p < 0.01$) and tenderness ($p < 0.05$) after the treatment than before. No such changes occurred in the DL group; indeed, secondary weakness and tenderness increased slightly in the latter group after treatment.

The degree of pain, tenderness and weakness of the two groups was similar before treatment. Comparing the two groups after treatment, L had less pain ($p < 0.05$) and less weakness ($p < 0.001$) than DL.

These data suggest that, in this small group of patients, laser therapy, advice and education improved certain symptoms of supraspinatus tendinitis, while the same advice and education but treatment with a dummy laser had no such beneficial consequences. Based on the results, low-power laser therapy with the parameters and dosage used in this study is recommended as a useful treatment for tendinitis, but the trial was limited by small numbers.

## Introduction

Laser energy is used increasingly by physiotherapists to treat soft tissue lesions. There have been few clinical trials to assess the efficacy of such treatments. The results have been conflicting; some studies have demonstrated efficacy,[1] other have not demonstrated useful effects.[2-4]

Much of the research on laser therapy has been *in vitro* or in animals; the resulting effects are said to result from the stimulation of cellular activity[5,6] and are effects that could be used profitably in the

Address for correspondence: Liz Saunders, Physiotherapy Department, Derby City General Hospital, Uttoxeter Road, Derby DE22 3NE, UK.

treatment of soft tissue lesions.

In tendinitis lasers are used to reduce inflammation, relieve pain and stimulate repair, but these effects may also be produced by using a placebo[7] and by resting the tendon from offending functional activity.[8]

The depth to which low-power laser energy penetrates the tissue is disputed; values between 2 mm and 40 mm are cited in the literature.[9] If the laser energy does not penetrate to the tendon, response to treatment might be due to placebo effects, or may result from the stimulation of more superficial cells mediating effects in the deeper tissues.[10]

Lasers have a high tech image and this creates an aura of expectation in physiotherapists and patients, enhancing the chances of alleviation of symptoms. This study addresses the question of the efficacy of low-power laser therapy and the possibility of placebo effects.

Previous studies of laser treatment of shoulder tendinitis have calculated the dose at the point of exposure on the skin. If the laser beam is directed at the site of tenderness, and the tissue is subcutaneous, the incident dose may not be sufficient to stimulate the cells that lie in the subcutaneous tissues. A study by Vecchio *et al.* on rotator cuff tendinitis used 3 J on each tender spot twice a week for eight weeks[4] and found no difference between the laser and dummy laser group. England *et al.*,[1] using a 3 mW probe for five minutes three times a week for two weeks, found a significant difference between laser and dummy laser in the treatment of supraspinatus tendinitis and bicipital tendinitis, but there was a difference in the presenting objective measurements for range of shoulder flexion between the study groups; in the laser group seven out of 10 subjects had over 100° of flexion, compared with four out of 10 in the dummy group and only one out of 10 in the control group, suggesting that the randomization of subjects had resulted in unequal groups. Chan *et al.*[3] used a dose of 0.3 J to treat tendinitis at the elbow with negative results and postulated that a larger dose along with greater area of exposure might have produced a positive result for laser therapy. Ohshiro[10] argues that longer exposures of laser therapy are more beneficial than shorter exposures, particularly in the earlier stages of treatment. The dose used in this study is a large dose, at 30 J/cm$^2$, in comparison with doses used in most of the previous studies on tendinitis and is 7.5 times greater than the therapeutic dose of 4 J/cm$^2$ for incident energy density,[11] as recommended by the laser manufacturer[12] for treatment at subcutaneous tissue levels.

## Method

### Subjects

The sample consisted of 24 consecutive patients referred by general practitioners and consultant rheumatologists presenting at a physiotherapy department with supraspinatus tendinitis. The diagnosis was made by the referring doctor. The criteria for inclusion were: age 35–65 years; a diagnosis of supraspinatus tendinitis of over four weeks' duration; no treatment during the last four weeks; and no other painful musculoskeletal or neurological condition. The age range was chosen to target patients in stages 2 or 3 of tendinitis as described by Bonnutti and Hawkins[8] and due to the known relationship between age and shoulder pain in industry.[13,14]

Consent to carry out the study was granted by the local Ethical Committee. All subjects gave informed consent to their inclusion in the trial.

The diagnosis was based on the signs and symptoms described as 'the empty can syndrome'[15,16] due to the similarity to the position adopted when emptying the contents of a can into a saucepan on the hob and found in electromyographical studies to be the best position to test supraspinatus isometrically. The criteria were: a full passive range of movement of the shoulder, but with impingement on full elevation; pain leading to secondary weakness on isometric contraction of the supraspinatus muscle with the arm in 1.57 rad (90°) of abduction, 0.52 rad of flexion and medially rotated so that the subject's thumb points directly downwards (Figure 1); and tenderness on palpation of the tendon medial to the point of insertion on the head of humerus.[17]

The subjects were randomly assigned to two treatment groups, L and DL, matched for gender as women have been found to be more likely to develop shoulder problems when working in production industries than men.[13] The women were younger than the men (Table 1) and more likely to be under 50 (chi square = 6.0 , $p < 0.05$).

**Figure 1** The position used for testing the supraspinatus muscle

The groups were of similar age range (Table 2). Duration of symptoms ranged from one to 10 months (Table 3).

### Advice

After agreeing to join the study, all subjects were given exactly the same advice on how to use their arm. This was important as advice may help to settle the symptoms down. Whilst in the department, the subjects were left alone to listen to a tape recording of a physiotherapist giving advice to patients with supraspinatus tendinitis. They listened to the tape once and then were given a written version of the same advice.

### Before-and-after measurements

The subjects were tested by the same independent 'blind' assessor before and after the course of nine treatments. The assessor did not know from which group the patients came.

### Pain

Perceived pain was assessed by the patient's using Huskisson's horizontal pain analogue scale[18] and also by their keeping a pain diary. The pain diary was used in addition to the scale to assess the patient's perceived pain over a 24-hour period.

The first pain analogue scale was completed at the first assessment, the second after the treatment, by asking the patient to judge their pain when using the arm and to put a mark on the scale in accordance with their judgement.

The pain diary was based on the Oswestry low back pain questionnaire[19] adapted for shoulder pain. The patients took the diary home and were asked to complete it on two occasions, each over a period of 24 hours; the first before the treatment, the second at the end of the course of treatment. They were specifically asked about pain at rest and when using the arm, and pain at different times of the day.

In the pain analogue scale the amount of change was calculated in millimetres for each patient: the changes that occurred in each group were calculated and the groups compared.

The scores for the pain diary were calculated for each patient on the basis of whether they had improved, stayed the same, or deteriorated, in the six questions relating to the different situations in the 24 hours. In each situation there was a four-

**Table 1** Number of subjects by gender in each age group

| | Age (years) | | | Total |
|---|---|---|---|---|
| | 35–45 | 46–55 | 56–65 | |
| Women | 6 | 2 | 4 | 12 |
| Men | 1 | 4 | 7 | 12 |

**Table 2** Age (years) of total sample ($n = 24$) and groups L and DL ($n = 12$)

| Subject | Mean | SD | Median | Range |
|---|---|---|---|---|
| Total | 50.25 | (8.23) | 52 | 37–64 |
| DL | 50.7 | (8.31) | 52 | 39–64 |
| L | 49.8 | (8.12) | 50 | 37–63 |

**Table 3** Duration of symptoms (month), total sample ($n = 24$) and groups ($n = 12$)

| Subject | Mean | SD | Median | Range |
|---|---|---|---|---|
| Total | 3.61 | (2.16) | 3 | 1–10 |
| DL | 3.32 | (1.9) | 3 | 1–7 |
| L | 3.86 | (2.4) | 3.5 | 1–10 |

point scale, e.g. no, slight, moderate and severe pain. An example of a question from the diary is shown below:

> By late afternoon with my arm still:
> My arm pain is severe
> My arm pain is moderate
> My arm pain is slight
> I have no arm pain

An improvement was given a positive score, one point for each step change that the patient noted. A deterioration was scored negatively, each step on the scale once again represented by a score of one. If the response remained unchanged a score of zero was given. The maximum for each question was three, the minimum minus three; no change was designated by zero. The scores for each of the six questions were summed, giving an indication of the change that had been noted between before and after the course of treatment. The patients were ranked according to their total score and the two groups were then compared using the Mann–Whitney U-test.

**Muscle contraction**

Maximum voluntary contraction (MVC) was measured with the arm in the 'empty can' position (Figure 1). Subjects were asked to hold up their arm as long as they could while the myometer (Penny and Giles Transducers Ltd, Christchurch, UK) was pushed downwards; they thus contracted the muscle with as much force as possible by trying to lift their arm upwards.

The myometer was used to test the muscle force.[20] The cuff of the myometer was placed just proximal to the lateral epicondyle of the humerus of the seated subject. The assessor quickly increased the resistance, causing the subject to apply their maximum counterforce. The myometer is a peak-measuring device, so the reading left on the display was the maximum muscle force sustained by the patient. Three measurements were made of each subject on the two occasions. The readings were averaged. The changes in muscle force required to reach break point between the two tests were calculated. The two groups were compared by calculating the change in MVC that had occurred between the two. The before-and-after treatment readings were compared within each group.

**Tenderness**

Tenderness was tested by removing the cuff from the myometer and the head was used to apply pressure perpendicularly, slowly and gradually to the tendon just medial to the point of insertion on the humerus. The reliability of this method of assessing tenderness has been established.[21,22] Fischer[23] found a disc plunger of 10 $mm^2$ effectively measured deep tissue tenderness in muscle and tendons. The subjects were asked to say 'yes' or move their shoulder away as soon as they felt tenderness. The reading on the display was the pressure at which the tenderness was first felt. The measurement was repeated three times in each test and averaged, and the change in tenderness between before and after treatment was calculated. The two groups were compared by calculating the change in tenderness that had occurred between the two tests. The before-and-after readings were compared within each group.

**Treatment**

A series of nine treatments was given to each patient over a three-week period. The patients were treated three times per week for 180 seconds. The standardized treatments were administered by two physiotherapy helpers who had been given on-the-job training and training on laser safety procedures. The helpers used probe A or B depending on the treatment group of the patient. The helpers did not know which of the probes was real and which was the dummy. They talked to the patients during their treatments, but offered no additional advice.

Two 50 mW, 820 nm (infrared) laser probes (Omega Universal Technologies Ltd, London, UK) identical in appearance were used, one a dummy. The wavelength and power were chosen due to their penetration properties.[9] There was no way for the helpers or therapists to distinguish between the probes. The power of the active probes was checked before, during and after the study. It was operated at 40 mW, 30 $J/cm^2$ at the surface; the dummy probe was at zero power. During treatment the probe was pressed firmly into the tissue, at an angle of 1.57 rad to the tendon and operated for 90 seconds at a frequency of 5000 Hz. Two areas were irradiated: the first the anterior shoulder, at the point of maximum tenderness just medial to the tendon's

insertion with the arm at the side and the forearm resting on the abdomen; the second the tendon just below the acromion with the patient's hand placed behind the back at L3 level.

### Analysis

Ranked data from the pain diary test before and after treatment were compared using the Mann-Whitney U-test. Unpaired *t*-tests were used to compare pain analogue scale, muscle force and tenderness changes of the two groups before and after treatment. Paired *t*-tests were used to compare the before-and-after data within each group for muscle force and tenderness. A chi-squared test was used to compare the ages of women and men and the groups.

## Results

The two treatment groups were compared before treatment. There was no significant difference between the two groups before treatment in relation to all the tests. The two groups were compared after treatment. A comparison was made for changes within each group before and after treatment.

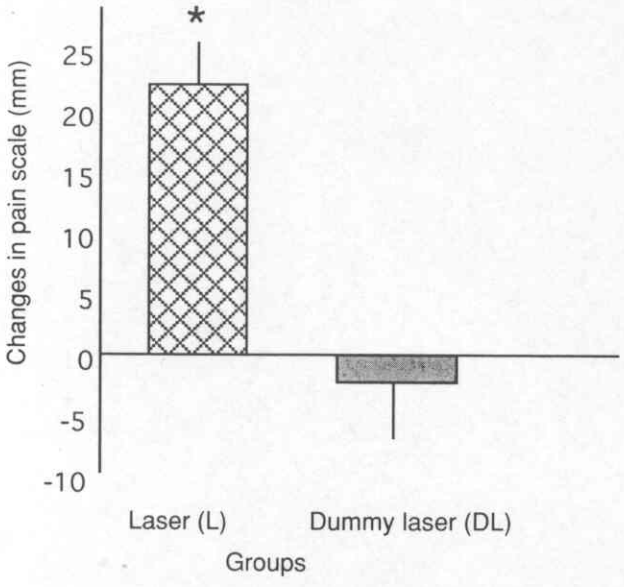


**Figure 2** The difference in pain analogue scale changes (mm) before and after treatment; a comparison between the two groups. The error bars represent one standard error of the mean (SEM). Difference between the two groups, * = $p < 0.05$.

**Table 4** Mean difference (median) between reported pain before and after treatment and its probability of being no greater than zero

| | Difference | *p* |
|---|---|---|
| Pain diary | Seven points (3.6) | $p < 0.05$ |

### Pain

More than 80% of patients in the L group improved after the series of treatments while only 20% improved in the DL group; and 50% thought that their pain was worse after the treatments; there was a significant difference between the changes in the two groups ($p < 0.05$; Figure 2).

More than 80% of the L group reported improvement of pain in their diaries (Figure 3); less than 50% of the dummy group reported any alleviation of pain ($p < 0.05$; Table 4).

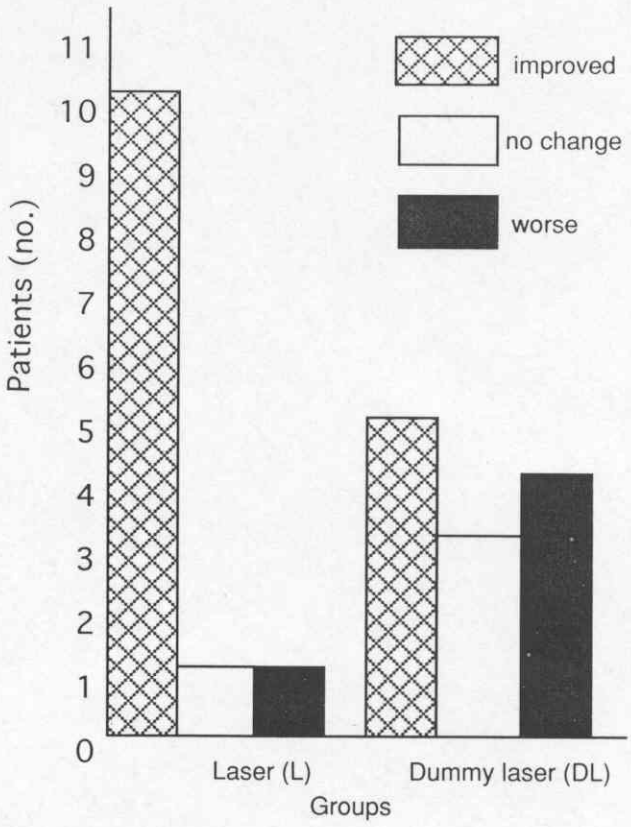


**Figure 3** Changes of pain experienced by the two groups (pain diary) before and after treatment. The columns show the numbers of patients whose pain improved, became worse and remained the same.

**Muscle force**

The L group had improved their muscle force ($p < 0.001$), whilst the DL group had remained unchanged (Figures 4 and 5).

**Tenderness**

There was a greater reduction in tenderness in the L group (Figure 6) than in the DL group ($p < 0.05$); however, when changes were analysed within each group, the laser group had not improved significantly ($p < 0.05$) and neither had the placebo group ($p > 0.05$) (Figure 7); although there was a trend towards improvement in the laser group ($p = 0.06$) that was not seen in the dummy group.

## Discussion

The results of this study suggest that advice along with dummy laser therapy failed to reduce the signs and symptoms of supraspinatus tendinitis. Identical advice and real laser treatment alleviated the signs and symptoms. Dummy laser, therefore, did not have a placebo effect in the DL group.

Laser therapy is said to cause photobiological biostimulation.[24] Studies *in vitro* and *in vivo* have produced a conflicting picture. Some researchers have demonstrated clear results, others not.[9] Whilst much work has been carried out to study the effects of laser on wound healing,[6] there is doubt that enough laser energy will pass through the skin to affect underlying soft tissue.[9] In this study a relatively high dose (30 J/cm$^2$) was used; this is seven and a half times greater than the therapeutic dose of 4 J/cm$^2$ usually used.[10] The results suggest that this dose might have allowed energy to penetrate to subcutaneous tissues in spite of absorption by the skin. The incident energy density used in the study was the energy density suggested for the treatment of subcutaneous tissues[11] and was tested before the study to ensure safety. It was postulated by Ohshiro[10] that

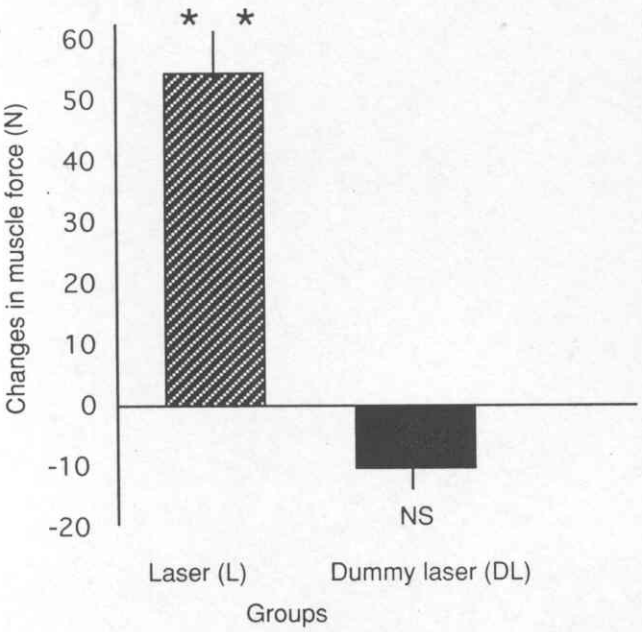


**Figure 4** The difference in muscle force changes before and after treatment; a comparison between the two groups. The error bars represent one SEM. Difference between the two groups, ** = $p < 0.005$, NS = $p > 0.05$.

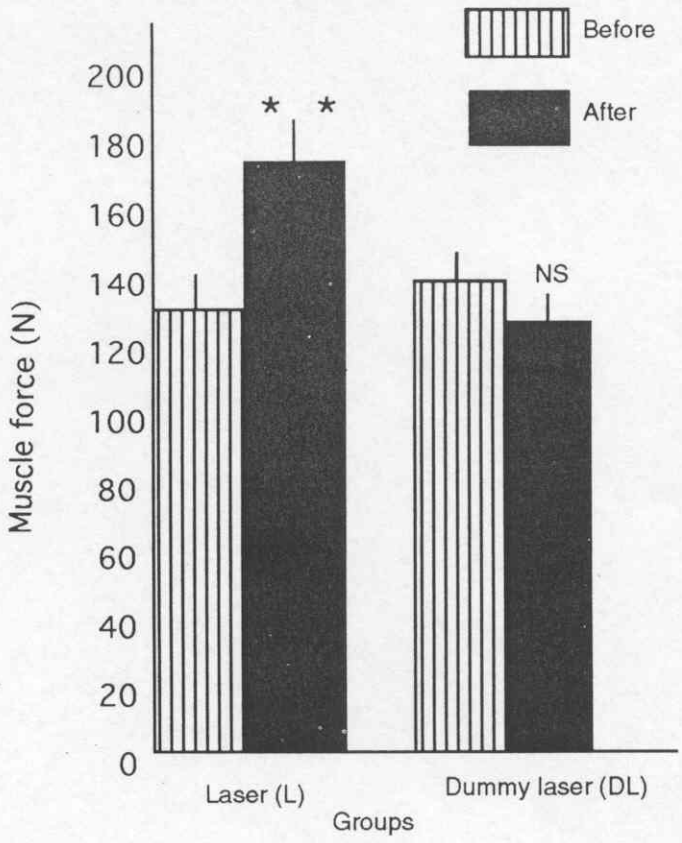


**Figure 5** The difference in muscle force (N) before and after treatment in the laser and dummy laser groups. The error bars represent one SEM. Difference between before and after, ** = $p < 0.001$, NS = $p > 0.05$.

the biostimulatory effects in the tissues may result from direct stimulation of the superficial cells with an indirect spread via the blood and lymphatic circulatory systems to produce reactions in more distant sites in the body; but the effective energy level is still unknown. In this study it has been revealed that there is a difference between the L and the DL group in pain felt and in muscle force following treatment. Tenderness was not significantly affected in either group, although the trend was towards alleviation in the laser group. These results suggest that the relatively high dose of 30 J/cm$^2$ used was effective in reducing the symptoms of tendinitis, along with advice to reduce functional activity, and may explain why some of the previous studies have failed to demonstrate efficacy. Incident energy densities of 3.6 J/cm$^2$ were used by Vasselgen,[25] who found that laser was significantly better than placebo but was no better than traditional physiotherapy in the treatment of tennis elbow. England *et al.*[1] did not specify an energy density, but from exposure time (five minutes) and calculations from the power of the probe used (3 mW) in contact, a low incident energy density of approximately 7.2 J/cm$^2$ was used to successfully treat shoulder tendinitis. Chan *et al.*[3] using a similar but lower-powered probe (1 mW) than England for the same exposure time (five minutes) found the slight improvement in the laser group was not significant either when comparing before-and-after treatment scores within the group, or in comparison with the dummy group; they postulated a higher dose and greater area of exposure may have been of more value therapeutically. Siebert *et al.*[2] used an apparently high power density of up to 7.5 J/cm$^2$ and found laser to be no more effective than placebo in the treatment of tendinopathies; however, the dose may have been considerably reduced by the fact that irradiation was from a distance of 10 cm using a GaAlAs diode and thus irradiated a spot area of skin 4 cm$^2$; according to

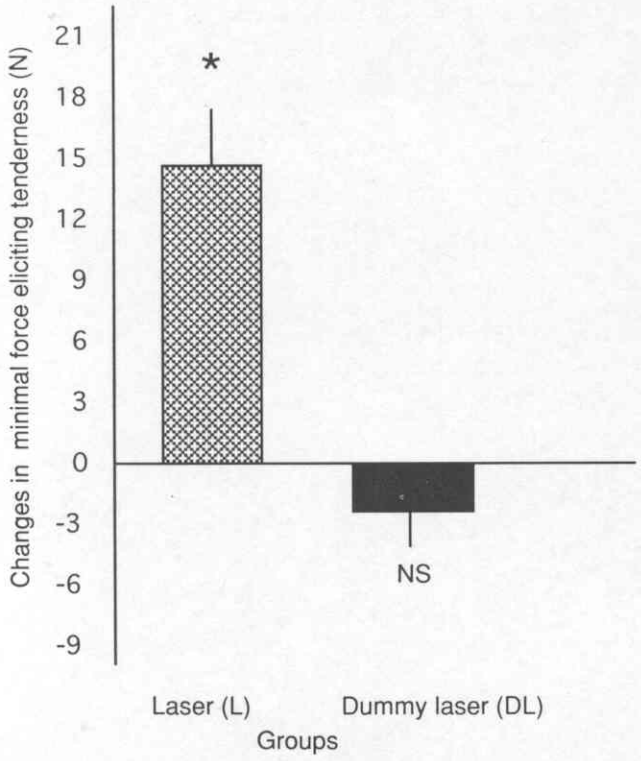


**Figure 6** The difference in changes of minimal force (N) required to elicit tenderness; a comparison between the two groups showing improvement in the laser group. The error bars represent one SEM. Difference between groups, * = $p < 0.05$, NS = $p > 0.05$.

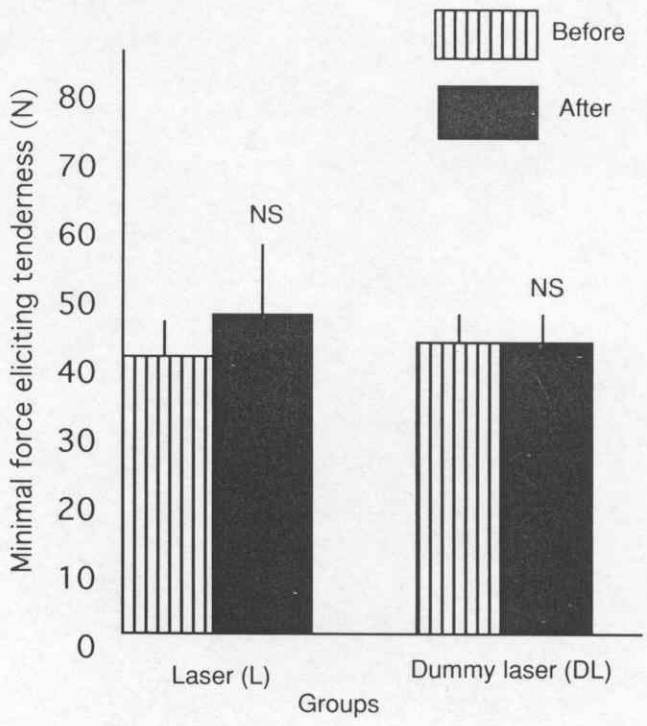


**Figure 7** The difference in minimal force (N) required to elicit tenderness before and after treatment in the laser group, where an improvement was seen, and dummy laser group, where there was no improvement. The error bars represent one SEM. Difference between before and after treatments, NS = $p > 0.05$.

the inverse square law, if the spot size is doubled, the power density is quartered, reducing somewhat the incident energy density, assuming the same power is delivered from the probe per spot size. Vecchio *et al.*[4] did use a higher incident dose of 3.0 J per point when treating rotator cuff tendinitis, finding both laser and placebo group improved in all measurements taken but that laser was no better than placebo. The supraspinatus tendon was actively exercised during the study, as the wall-climbing exercise given to patients to practise at home involved the action of the supraspinatus muscle and rotator cuff due to the functional arc of elevation of the shoulder being forward, not lateral,[26] an action deliberately avoided in this study and which could account for the different results.

Following the completion of their involvement in the study, laser therapy was offered to all of the patients. All accepted and all improved. Nine treatments were sufficient to elicit a significant change. Further improvement was achieved by continuing treatment, all patients being kept on treatment for at least three more weeks. It is not known if this continued improvement also would have occurred had treatment been stopped earlier, or indeed if fewer than nine treatments had been used in the study. Most patients were discharged still showing slight signs of supraspinatus tendinitis and were counselled to continue to protect the tendon, particularly for work-related tasks. Two subjects, who had nondominant arm involvement and little tenderness, began to develop signs of frozen shoulder.

The results of this study suggest that laser therapy may well be an effective treatment for supraspinatus tendinitis, using an 820 nm, 50 mW probe at 5000 Hz to produce an incident energy density of 30 J/cm$^2$, along with advice on rest from offending activity. It may well be an efficient treatment of choice, as the probe operating at 40 mW allowed the dose to be applied in just one and a half minutes compared with a thirteenfold increase that would be required to produce the same dose with a 3 mW probe. Further research is needed to examine the effects of different wavelengths, frequencies of pulses and probe powers. If it is shown to be beneficial in future trials, it may prove to be a cost-effective therapy. Thus advice and, in the case of supraspinatus tendinitis, thrice-weekly three-minute treatments could be the therapy of choice, enabling more patients to be treated effectively.

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