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# Efficacy of quadriceps vastus medialis dry needling in a rehabilitation protocol after surgical reconstruction of complete anterior cruciate ligament rupture

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## Abstract

**Background:** Several new rehabilitation modalities have been proposed after anterior cruciate ligament (ACL) reconstruction. Among these, trigger point dry needling (TrP-DN) might be useful in the treatment of myofascial pain syndrome associated with ACL reconstruction to reduce pain intensity, increase knee flexion range and modify the mechanical properties of the quadriceps muscle during late-stage rehabilitation. To date, this is the first randomized clinical trial to support the use of TrP-DN in the early rehabilitation process after ACL reconstruction. The aim of this study was to determine the pain intensity, range of motion (ROM), stability, and functionality improvements by adding quadriceps vastus medialis TrP-DN to the rehabilitation protocol (Rh) provided to subacute ACL reconstructed patients.

**Methods:** This randomized, single-blinded, clinical trial (NCT02699411) included 44 subacute patients with surgical reconstruction of complete ACL rupture. The patients were randomized into 2 intervention groups: Rh (n = 22) or Rh + TrP-DN (n = 22). Pain intensity, ROM, stability, and functionality were measured at baseline ($A_0$) and immediately ($A_1$), 24 hours ($A_2$), 1 week ($A_3$), and 5 weeks ($A_4$) after the first treatment.

**Results:** Comparing statistically significant differences ($P \leq .001$; $Eta^2 = 0.198–0.360$) between both groups, pain intensity (at $A_1$), ROM (at $A_1$, $A_2$, and $A_3$), and functionality (at $A_2$, $A_3$, and $A_4$) were increased. Nevertheless, the rest of measurements did not show significant differences ($P > .05$).

**Conclusion:** Quadriceps vastus medialis TrP-DN in conjunction with a rehabilitation protocol in subacute patients with surgical reconstruction of complete ACL rupture increases ROM (short-term) and functionality (short- to mid-term). Although there was an increase in pain intensity with the addition of TrP-DN, this was not detected beyond immediately after the first treatment. Furthermore, stability does not seem to be modified after TrP-DN.

**Abbreviations:** ACL = anterior cruciate ligament, ROM = range of motion, Rh = rehabilitation protocol, TrP-DN = trigger point dry needling.

**Keywords:** anterior cruciate ligament, anterior cruciate ligament reconstruction, myofascial pain syndrome, physical therapy modalities, rehabilitation, trigger points

# 1. Introduction

Onehundred thousand anterior cruciate ligament (ACL) ruptures occur in the Unites States of America every year. An incidence between 80,000 and 250,000 ACL ruptures was estimated in young athletes.[1] The prevalence of ACL and meniscal injuries could be as high as 0.35%, and risk is increased by higher body height or mass index (BMI). ACL is associated with secondary osteoarthrosis and can lead to functional impairment and economic burden.[2] The recent increase in the frequency of ACL injuries might be related to an increase in school sports participation. ACL mostly arises via noncontact mechanisms. Although radiographs are used to rule out associated conditions, magnetic resonance imaging (MRI) is the criterion standard diagnosis method for ACL rupture.[3]

ACL arthroscopic reconstruction surgery typically involves autologous graft, such as the central third of the patellar tendon or the flexor tendons (semitendinosus and gracilis). The results and complications of such approaches are well described in the literature.[4] A lengthy rest period is usually required after surgical reconstruction of complete ACL rupture. Although new methods have been proposed to shorten the time required for the graft healing process, the clinical and pain improvements of these methods remain controversial.[5]

Several new rehabilitation modalities have been proposed after ACL reconstruction. Range of motion (ROM), strengthening, early high-intensity electrical stimulation, and functional exercises have been proposed as beneficial supplementary treatments during rehabilitation. There is no evidence to suggest that accelerated rehabilitation is harmful. However, further research is needed to evaluate rehabilitation timing and clinical improvement when supplementary treatments are applied.[6]

Despite the lack of studies about trigger points prevalence or incidence in this condition, trigger point dry needling (TrP-DN) treatment has been proposed as a useful addition to the rehabilitation of ACL reconstructed patients with myofascial pain syndrome (MPS), reducing pain intensity, increasing knee flexion range, and modifying the mechanical properties of the quadriceps muscle during late stage rehabilitation.[7] Indeed, MPS may be considered as a set of sensitive, motor or autonomic signs and symptoms generated by hyperirritable spots in a muscle taut band, which are myofascial trigger points (MTrPs).[8] Active MTrPs may produce spontaneous and recognized pain in patients with MPS.[9] Recently, a systematic review addressing dry needling (DN) in subjects with MTrPs in the lower quarter concluded that TrP-DN is effective at reducing pain in the short term. Nevertheless, further research is needed to investigate the effect of TrP-DN in conjunction with other interventions.[10] A single treatment of TrP-DN (under anesthesia) before total knee arthroplasty was shown to be superior to placebo in reducing pain intensity after 1 month.[11] Also, the addition of TrP-DN to a proprioceptive and strengthening exercise program was able to improve function and stability in the lower limb.[12] Finally, the passive mechanical properties and referred pain elicited by active MTrPs in the vastus medialis may improve after TrP-DN intervention.[7]

To date, this is the first randomized clinical trial (RCT) to support the use of DN in the early rehabilitation process after ACL reconstruction. Accordingly, the aim of this study was to determine the pain intensity, ROM, stability, and functionality improvements in mid term after quadriceps vastus medialis TrP-DN in conjunction with a rehabilitation protocol after surgical reconstruction of complete ACL rupture.

# 2. Material and methods

## 2.1. Design

A single-blinded RCT was carried out from February 2016 to January 2017, following the CONSORT guidelines, flow diagram, and checklist.[13] Therefore, a blinded evaluator and a consecutive sampling method were used. Randomization into 2 intervention groups was performed "per protocol" using opaque closed letter envelopes.

## 2.2. Ethical and trial registry

First, the Ethics Committee of *Nuestra Señora de Sonsoles* Hospital (Ávila, Spain; November 26, 2015) approved the study. Second, the protocol was registered at Clinicaltrials.gov (February 26, 2016) with a number clinical trial identifier (NCT02699411). Finally, the informed consent forms were signed by all subjects before the beginning of the study. The required local regulations and ethical standards for human experimentation of the Declaration of Helsinki were respected.[14]

## 2.3. Sample size

According to Mayoral et al,[11] a convenience sample of 40 patients was considered sufficient, with an additional 10% to allow for possible patient loss during follow-up. Therefore, 44 participants were recruited at the *FisioSalud Ávila* (Ávila, Spain) private clinical center and divided into 2 intervention groups (n = 22 per group).

## 2.4. Inclusion and exclusion criteria

The inclusion criteria were: 18- to 55-year-old subjects, in the subacute phase (from 7 to 21 days) after unilateral surgical reconstruction of complete ACL rupture, confirmed by MRI in the medical record.[7] Also, the presence of at least 1 active MTrP in the vastus medialis ipsilateral to ACL rupture had to have been detected by palpation following the recommended clinical diagnostic criteria (nodule, taut band, spontaneous and patient's recognized pain, and ROM limitation at full stretch).[7,11]

The exclusion criteria were: bilaterally previous diagnoses in the medical record, such as neuropathic pain in the lower limb, lumbosacral radiculopathy, saphenous nerve entrapment, meralgia paresthetica, fractures, rheumatoid or systemic conditions, other surgeries, post-surgery complications (i.e., thrombosis or osteomyelitis), belonephobia, legs lenth difference in the lower limb (>0.5 cm), and the presence of any condition considered an MTrPs perpetuating factor (i.e., fibromyalgia, hypothyroidism, or iron deficiencies).[7,11]

## 2.5. Sociodemographic and descriptive data

The sociodemographic descriptive characteristics were collected at baseline: sex (male or female), age (years), number of associated injuries to ACL rupture (meniscopathy, ligament injuries, or chondropathy),[2] TrP-DN adverse effect (considering hemorrhages >4 cm$^2$),[15,16] use of heparin during TrP-DN,[17] postsurgery time (days from the surgery to the beginning of the rehabilitation protocol),[6] and ACL reconstruction surgery type (patellar bone-tendon-bone or hamstring tendon grafts methods).[4–6]

## 2.6. Outcome measurements

Pain intensity was the primary outcome. In addition, ROM, stability, and functionality were the secondary outcomes. Pain intensity, ROM, and functionality outcome measurements were performed at baseline ($A_0$), immediately after the first intervention ($A_1$), as well as 24 hours ($A_2$), 1 week ($A_3$), and 5 weeks ($A_4$) after the first treatment day (before the treatment beginning on this day). Stability was only assessed at $A_3$ and $A_4$. All assessments were carried out by a blinded examiner. The assessment times were chosen to coincide with the different TrP-DN stages of muscle regeneration and reinnervation (in short term [$A_1$, $A_2$, and $A_3$] and mid term [$A_4$]).[18]

First, the pain intensity was assessed using the visual analogue scale (VAS) of 10 mm (from 0 [no pain] to 10 mm [maximum pain]). Patients marked on the scale their spontaneous subjective pain intensity of the affected ACL knee using a marker pen. The VAS is a recommended, reliable, and valid tool, and had been previously used in knee conditions after TrP-DN.[7,11,19]

Second, the ROM was evaluated with an analogue universal goniometer (UG), which is a 0 to 360 degree plastic instrument with $2 \times 25$ cm moveable arms and a scale marked in 1 degree increments. The prone position, the lateral femoral epicondyle coinciding with the center of the fulcrum, and the 0 degree normal physiological full knee extension were considered to assess the knee flexion movement parameter. The UG has been shown to be a reliable and valid and has been recommended for use in clinical practice for adults with musculoskeletal conditions of the knee, as well as been used in previous TrP-DN studies.[7,11,20]

Third, stability was measured using the Star Excursion Balance Test (SEBT). The SEBT is a reliable and valid objective measure for identifying deficits and improvements in dynamic postural control related to lower extremity conditions and induced fatigue. The recommended protocol of 5 repetitions in each of the 8 directions of the star (anterior, posterior, medial, lateral, anteromedial, anterolateral, posteromedial, and posterolateral) was applied. The distance from the star center (coinciding with the affected ACL lower extremity) to the farthest marked point (with the distal part of the nonaffected lower limb) for each star direction was measured in centimeters. The final punctuation was calculated with the mean of the 5 repetitions in each star direction, divided by ($8 \times$ lower limb length) cm and multiplied by 100.[21,22]

Finally, The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used to measure the physical function of the knee. This scale was shown to be a valid and reliable tool, which was utilized to assess the physical function in patients with knee surgery after TrP-DN. This tool comprises 24 questions: 5 questions about pain (0–20 points), 2 questions about stiffness (0–8 points), and 17 questions about physical functions difficulty (0–68 points), which may be completed in <5 minutes. Higher WOMAC scores indicate a larger deterioration degree.[11,23,24]

## 2.7. Intervention

The patients were randomly assigned into 2 intervention groups, which received either the rehabilitation protocol plus TrP-DN (Rh + TrP-DN group; n = 22) or the rehabilitation protocol only (Rh group; n = 22). Both groups were treated by an experienced physical therapist with >6 years and 30 hours per week of clinical practice, following the previous recommendations to achieve a good interexaminer reproducibility ($\kappa = 0.63$) in the active MTrPs palpation diagnosis.[25]

Only 1 session of a TrP-DN intervention on the most hyperalgesic active MTrP of the vastus medialis ipsilateral to the affected ACL knee was applied on the first treatment day of the Rh + TrP-DN group. The most hyperalgesic active MTrP was marked with a grid of 4 perpendicular lines and considered to be the one that elicited the highest recognized pain sensation in the VAS under the same palpation pressure.[26] The Hong fast-in and fast-out technique with multiple rapid needle insertions was performed following previous recommendations.[27] The patient was placed in supine decubitus with their knee passively flexed at 30 degree.[7,11] A headless $0.25 \times 25$-mm needle (Stainless steel, Agupunt A1038P, 158 Caspe, Barcelona, Spain) was fixed between the fingers of the nondominant hand and inserted perpendicular to the MTrP with a metacarpophalangeal flexion-extension of the first to second fingers of the dominant hand (Fig. 1). The MTrP area was probed in various directions until production of at least 1 local twitch response (LTR), a pain response, and, usually, the recognized MTrP-referred pain pattern of the MTrP. The penetration depth varied according to the subject. TrP-DN was carried out during 1 to 2 minutes until reaching LTR exhaustion, patients' tolerance limit, or a maximum of 20 needle insertions. Finally, hemostasis was performed for 1 minutes.[7,11,26] Furthermore, TrP-DN was performed medial to the sartorius muscle limit to avoid saphenous nerve adverse effects during TrP-DN.[28] The number of LTRs was visually observed during each TrP-DN intervention to determine their influence on the outcome measurements.[15,16]

The rehabilitation protocol was applied in both intervention groups (Rh+TrP-DN and Rh groups) during a 5-week period (from Monday to Friday). This daily protocol consists of manual passive joint mobilization (20 repetitions of flexion-extension at 60 degree per second; supine position), active assisted joint mobilization (20 repetitions of flexion-extension at 60 degree per second; supine position), isometric contractions of quadriceps and hamstrings (12 repetitions × 3 series; interval for 12 seconds between repetitions; interval for 15 seconds between series; knee flexed at 15 degree and supine position), quadriceps electrical stimulation (Kotz electric current applied with 4 electrodes; medium basal frequency of 2500 Hz; pulse trains frequency of 50 Hz; intensity determined by the patient's threshold; maximum isometric contraction during 6 seconds of active electrical stimulation phase; interval duration 12 seconds; supine position; 15 minutes of treatment following 5 minutes of warm-up), closed kinetic chain strengthening eccentric exercise (squat exercise in standing position; knee flexed at 45 degree for 10 seconds; 15 repetitions with 20-second intervals), open kinetic chain



**Figure 1.** Trigger point dry needling intervention in the vastus medialis active myofascial trigger point of the affected anterior cruciate ligament knee.

Velázquez-Saornil et al. Medicine (2017) 96:17

**Medicine**



**Figure 2.** Progressive proprioceptive exercises protocol with the affected anterior cruciate ligament lower limb. (A) Monopodial exercise with open and closed eyes; (B) monopodial exercise with rotational trunk movement; (C) monopodial exercise associated with instability by external stimulus; (D) step-by-step sequence associated with squat eccentric exercise; (E) monopodial exercise associated with instability by different movement directions; (F) monopodial exercise associated with instability by different movement combinations; (G) monopodial exercise in standing position associated with instability platforms; and (H) monopodial exercise in sedestation position associated with instability platforms.

strengthening concentric exercise (10 repetitions × 3 series from 90 degree flexion to 0 degree extension for quadriceps and from 0 degree extension to 90 degree flexion for hamstrings; 60% to 75% of maximum intensity, medium velocity and 3–5-minute intervals; sedestation position), proprioceptive exercises (15–20 minutes; 8 progressive exercises described in Fig. 2; 30 seconds per exercise; interval of 60 seconds between exercise), cycle ergometer, and walking aerobic exercise (20 minutes at medium intensity).[6]

### 2.8. Intraexaminer reliability of MTrP location

An intraexaminer reliability study of the most hyperalgesic active MTrP in the vastus medialis of the affected ACL knee was carried out by the physical therapist who performed the intervention. The distance (centimeters) from the most hyperalgesic active MTrP of the vastus medialis to the femoral medial epicondyle was measured at 2 different moments with an interval of 1 hour.[26]

### 2.9. Data analysis

The statistical analysis was performed using SPSS (version 23.0 for Windows, IBM SPSS Statistics for Windows; IBM Corp, Armonk, NY) and an $\alpha$ error of 0.05 (95% confidence interval [CI]) with a desired power of 80% ($\beta$ error of 0.2). Initially, the Shapiro-Wilk test was carried out to assess normality. The descriptive analyses for quantitative (minimum, maximum, mean, and standard deviation [SD]) and qualitative (absolute and relative frequency) variables were performed. Considering the normal distribution and homogeneity of variances (Levene test), Student $t$ or $\chi^2$ tests were used to compare the groups. A linear general model of analysis of variance (ANOVA) was made to determine the effects of time (outcome measurement moments: $A_0$, $A_1$, $A_2$, $A_3$, and $A_4$) and intervention group (groups: Rh + TrP-DN or Rh). Therefore, a mixed factorial ANOVA or a partial repetitive measurements ANOVA, completed with the Greenhouse-Geisser sphericity correction analysis, was used to study the intrasubject effects (measurement moments), intersubject

Velázquez-Saornil et al. Medicine (2017) 96:17

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**Table 1**

Baseline comparison of both groups between sociodemographic, descriptive, and outcome measurements.

| Measurements | Treatment group | | $\chi^2$ (Df) | P |
| --- | --- | --- | --- | --- |
| | Rh + TrP-DN (n = 22) | Rh (n = 22) | | |
| Sex, n (%) | | | 1.57 (1) | .21 |
|   Men | 16 (72.7) | 12 (54.5) | | |
|   Women | 6 (27.3) | 10 (45.5) | | |
| Surgery type, n (%) | | | 0.09 (1) | .763 |
|   H-T | 11 (50) | 12 (54.5) | | |
|   B-T-B | 11 (50) | 10 (45.5) | | |
| Heparin, n (%) | | | 0.83 (1) | .361 |
|   No | 8 (36.4) | 11 (50) | | |
|   Yes | 14 (63.6) | 11 (50) | | |
| Adverse effects, n (%) | | | 3.22 (1) | .073 |
|   No | 19 (86.4) | 22 (100) | | |
|   Yes | 3 (13.6) | 0 (0) | | |
| Associated injuries, n (%) | | | 3.47 (2) | .177 |
|   No | 9 (40.9) | 5 (22.7)) | | |
|   1 Injury | 10 (45.5) | 9 (40.9 | | |
|   2 Injuries | 3 (13.6) | 8 (36.4) | | |
| | | | t (Df) | P |
| Postsurgery time, days, range; mean (SD) | 13–18; 15.6 (1.5) | 12–19; 15.5 (2.0) | 0.17 (42) | .865 |
| Age, y; mean (SD) | 19–46; 31.4 (8.3) | 19–51; 34.4 (8.6) | −1.18 (42) | .244 |
| VAS range; mean (SD) | 5–8; 6.9 (0.9) | 5–8; 6.6 (0.9) | 1.04 (42) | .305 |
| WOMAC range; mean (SD) | 59–76; 69.1 (4.2) | 60–76; 68.1 (4.4) | 0.71 (42) | .481 |
| ROM (degree) range; mean (SD) | 60–110; 93.2 (10.4) | 70–100; 89.1 (8.1) | 1.45 (42) | .153 |

B-T-B = patellar bone-tendon-bone graft method, Df = degrees of freedom, H-T = hamstring tendon graft method, Rh = rehabilitation protocol, ROM = range of motion, SD = standard deviation, TrP-DN = trigger point dry needling, VAS = visual analogue scale, WOMAC = The Western Ontario and McMaster Universities Osteoarthritis Index.

effects (treatment group), and their interaction. The effect size was calculated by means of the Eta$^2$ coefficient. Furthermore, an analysis of covariance (ANCOVA) was performed to determine the LTRs effect in the outcome measurements of the Rh + TrP-DN group.

In addition, a multiple regression analysis was carried out to determine the variables which produced a significant effect on the outcome measurements (VAS, WOMAC, and ROM) after 24 hours of the intervention. The followed methodology was calculated by punctual estimation of the model parameters, individual significance of the variables and model constant, regression contrast (ANOVA) to study the model global validity and verify the coefficient of the prediction model, and model verification by the residues analysis.

Considering ρ as the intraclass correlation coefficient (ICC) and $k$ as the number of measurements ($k = 2$), the intrarater reliability study was based on the Spearman-Brown formula:

$$\rho k = \frac{k * \rho}{1 + (k-1) * \rho}$$

Therefore, the Spearman-Brown reliability index of $\rho k > 0.9$ was considered excellent intrarater reliability.

## 3. Results

### 3.1. Baseline measurements and flow diagram

Comparing the Rh and Rh + TrP-DN groups, we found no significant differences ($P > .05$) in the sociodemographic characteristics, descriptive data, or outcome measurements at baseline (Table 1). The flow diagram is shown in Figure 3.

### 3.2. Efficacy of both interventions

The differences in outcomes between the treatment groups are shown in Table 2 and Figure 4. Both intervention groups showed

statistically significant differences ($P < .001$) with a large effect size (Eta$^2$ coefficient from 0.962 to 0.980) between different measurement moments for VAS and WOMAC reductions, as well as ROM and SEBT increases. Comparing statistically significant differences ($P \leq .001$; Eta$^2$ coefficient from 0.198 to 0.360) between the groups, VAS scores were increased at $A_1$, WOMAC scores were reduced at $A_2$, $A_3$, and $A_4$, and ROM was increased at $A_1$, $A_2$, and $A_3$, in favor of the Rh + TrP-DN group. Nevertheless, the rest of measurement moments and SEBT did not show statistically significant differences ($P > .05$).

### 3.3. LTRs' effect in the outcome measurements

The covariance analyses to determine the LTRs effect in the outcome measurements of the Rh + TrP-DN group are shown in Table 3. The LTRs number obtained during TrP-DN did not influence the outcome measurements.

### 3.4. Multiple regression analysis

In addition, Table 4 shows the multiple regression analysis to determine the variables which produced a significant effect for ROM (adjusted $R^2 = 44.3\%$; $P < .001$) and WOMAC (adjusted $R^2 = 24.1\%$; $P = .008$) after 24 hours of the intervention. Nevertheless, there was not significant effect ($P > .05$) for VAS scale prediction.

### 3.5. Intrarater reliability for active MTrP location

The procedure used to identify the most hyperalgesic active MTrP location in the quadriceps vastus medialis had excellent intra-examiner reliability (ICC = 0.985; $\rho k = 0.992$). The mean (SD) distance between the identified MTrP and the knee medial epicondyle was 7.44 cm (0.58–0.71) and ranged from 6.20 (minimum) to 8.60 cm (maximum).
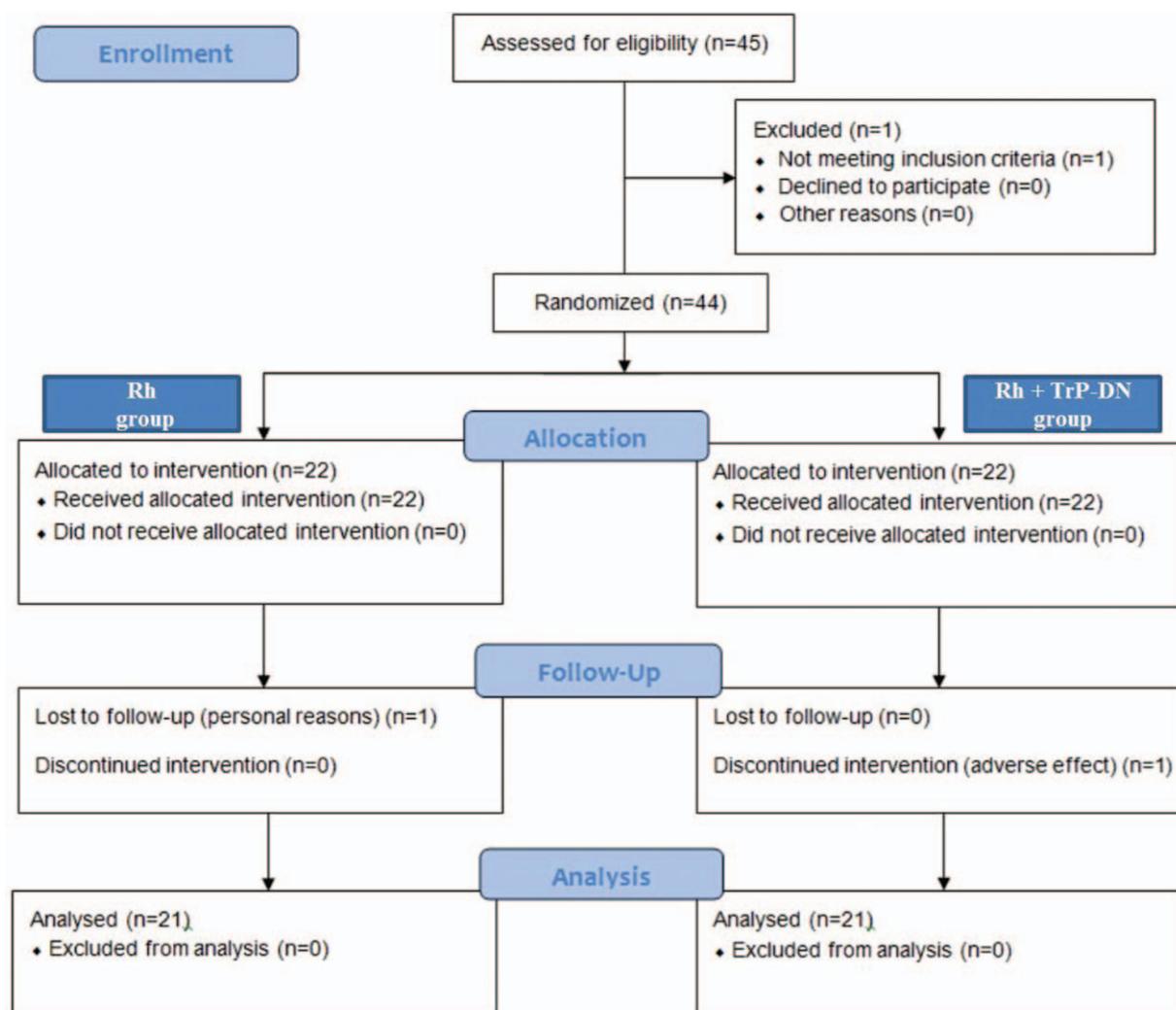
**Figure 3.** Flow diagram of the study participants in both intervention groups. Rh = rehabilitation protocol, TrP-DN = trigger point dry needling.

## 4. Discussion

Here we found that supplementing the rehabilitation protocol of surgically reconstructed ACL rupture patients with quadriceps vastus medialis TrP-DN increases ROM (short-term) and functionality (short- and mid-term) and that this is accompanied by an immediate increase in pain intensity.

Unlike our study, previous studies of TrP-DN in postsurgery knee conditions (e.g., arthroplasty or late stage rehabilitation of ACL reconstructed patients) did not detect an immediate increase in pain intensity.[7,11,29] The increased pain intensity that we detected with TrP-DN might be accounted for by the patients being intervened during the subacute postsurgery time, heparin treatment, and postneedling soreness.[30] Nevertheless, the VAS increase did not reach the 33% threshold of clinical significance nor 20% of the variability, according to Williamson and Hoggart.[19]

The secondary outcomes, short-term ROM, and mid-term functionality improvements were in line with previous studies.[7,11,29] The active nonweight-bearing ROM increase clinical significance only reached the 15 degree difference at 1 week (A₃) after TrP-DN, according to Aigner et al.[31] The WOMAC 20% difference between groups set the minimum clinically important difference at 5 weeks (A₄) after TrP-DN, according to Raynauld

et al.[32] Also, the dynamic postural control did not show differences from the 1st to 5th weeks after the treatment start. This outcome cannot be measured during the acute postsurgery period, and therefore was not included in our study. Nevertheless, a recent study found an improvement in the 6-minute walking test postintervention for patients with chronic postsurgical pain and MTrPs following total knee replacement.[7]

According to the covariance and multivariate analyses, the LTRs number obtained during TrP-DN did not influence the outcome measurements. This finding is different to other studies.[15,16] The WOMAC scale increased 0.36 U/kg/m² of BMI and 3.85 U in the Rh intervention versus Rh + TrP-DN treatment. ROM was decreased 0.45 degree per each age year increase and 14.51 degree in the Rh group versus Rh + TrP-DN group (Table 4). Our intraexaminer reliability for the most hyperalgesic MTrP location was excellent according to previous research.[26]

The TrP-DN adverse effects were considered as hemorrhages >4 cm², as was done in previous studies that applied TrP-DN during antiaggregants or anticoagulants therapy.[15,16] A headless 0.25 × 25-mm needle was used to avoid this adverse effect, which is smaller than the needles used in previous studies (headless 0.30 × 50-mm needles).[7,11] Three patients suffered

**Table 2**

**Efficacy of both interventions and outcomes differences in all measurement moments.**

| | Measurements | | | | | Effects | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | Baseline ($A_0$) | Post ($A_1$) | 24h ($A_2$) | 1 wk ($A_3$) | 5 wk ($A_4$) | Time | Treatment $\times$ time |
| Outcomes (n) | Mean (SD) | Men (SD) | Mean (SD) | Mean (SD) | Mean (SD) | F (Df); $P$ (Eta$^2$) | F (Df); $P$ (Eta$^2$) |
| **VAS** | | | | | | F (2.58; 103.21)=1.006.43; $P<.001$ (0.962) | F (2.58; 103.21)=24.56; $P<.001$ (0.380) |
| Rh+TrP-DN (21) | 6.86 (0.9) | 7.76 (0.8) | 6.52 (1.0) | 4.19 (1.2) | 1.81 (1.0) | | |
| Rh (21) | 6.57 (0.9) | 6.57 (0.9) | 6.52 (0.9) | 4.57 (1.0) | 2.29 (1.0) | | |
| Total | 6.71 (0.9) | 7.17 (1.0) | 6.52 (1.0) | 4.38 (1.1) | 2.05 (1.0) | | |
| **WOMAC** | | | | | | F (1.28; 51.32)=1.324.47; $P<.001$ (0.971) | F (1.28; 51.32)=9.86; $P=.001$ (0.198) |
| Rh+TrP-DN (21) | 69.16 (4.2) | 69.26 (4.2) | 64.48 (3.7) | 38.51 (9.0) | 14.08 (3.7) | | |
| Rh (21) | 67.75 (4.2) | 67.75 (4.2) | 67.75 (4.2) | 46.18 (10.9) | 18.60 (3.9) | | |
| Total | 68.46 (4.2) | 68.51 (4.2) | 66.11 (4.2) | 42.35 (10.6) | 16.34 (4.4) | | |
| **ROM** | | | | | | F (2.72; 108.77)=1.022.76; $P<.001$ (0.962) | F (2.72; 108.77)=13.73; $P<.001$ (0.255) |
| Rh+TrP-DN (21) | 92.86 (10.6) | 98.57 (8.5) | 104.76 (9.8) | 131.43 (11.5) | 159.05 (3.0) | | |
| Rh (21) | 89.05 (8.3) | 89.52 (8.6) | 90.00 (9.5) | 113.81 (11.6) | 156.19 (5.9) | | |
| Total | 90.95 (9.6) | 94.05 (9.6) | 97.38 (12.1) | 122.62 (14.5) | 157.62 (4.8) | | |
| **SEBT** | | | | | | F (1; 40)=1.960.56; $P<.001$ (0.980) | F (1; 40)=3.34; $P=.075$ (0.077) |
| Rh+TrP-DN (21) | | | | 58.50 (5.1) | 88.23 (5.4) | | |
| Rh (21) | | | | 58.56 (4.2) | 85.93 (4.8) | | |
| Total | | | | 58.53 (4.6) | 87.08 (5.2) | | |

Df = degrees of freedom, Rh = rehabilitation protocol, ROM = range of motion; SD = standard deviation, SEBT = start excursion balance test, TrP-DN = trigger point dry needling, VAS = visual analogue scale, WOMAC = The Western Ontario and McMaster Universities Osteoarthritis Index.

Outcome measurements at baseline ($A_0$), immediately after the first intervention ($A_1$), as well as 24 hours ($A_2$), 1 week ($A_3$), and 5 weeks ($A_4$) after the first treatment day (before the treatment beginning in this day).
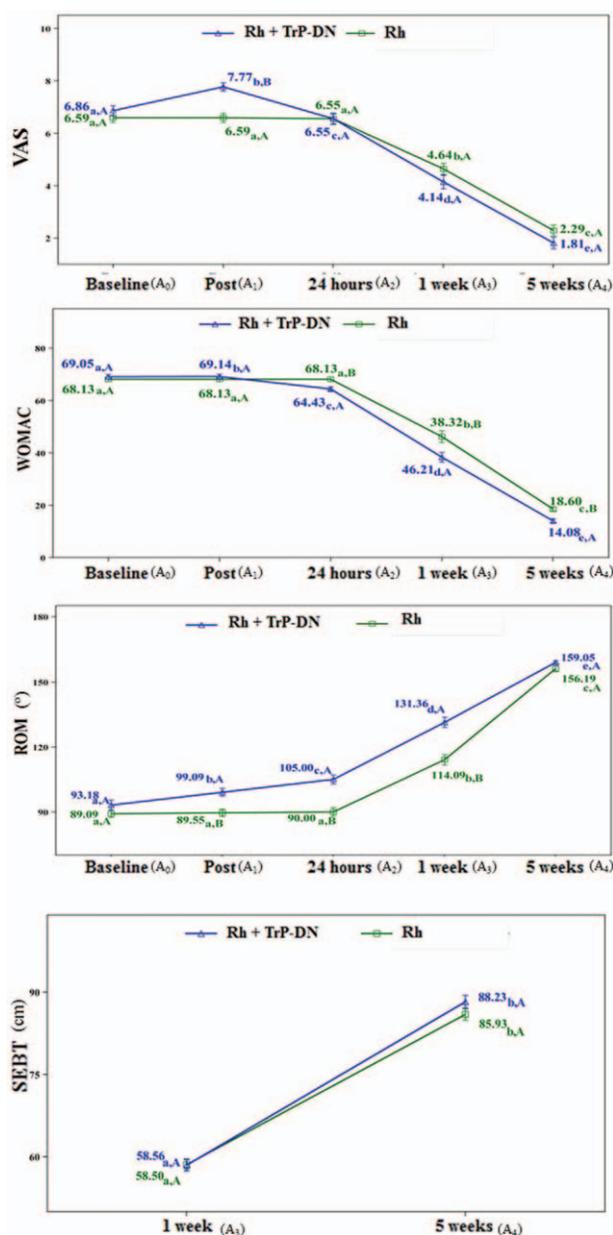
**Figure 4.** Box-plots to illustrate the differences in treatment outcomes between the tested groups. (A-E) Different lowercase letters indicate intragroup statistically significant differences (P < .05) between different outcome measurement moments (Bonferroni correction). (A and B) Different capital letters indicate intergroup statistically significant differences (P < .05) between both groups in the same outcome measurement moment (Bonferroni correction). Outcome measurements at baseline ($A_0$), immediately after the first intervention ($A_1$), as well as 24 hours ($A_2$), 1 week ($A_3$), and 5 weeks ($A_4$) after the first treatment day (before the treatment beginning on this day). Rh = rehabilitation protocol, ROM = range of motion, SEBT = star excursion balance test, TrP-DN = trigger point dry needling, VAS = visual analogue scale, WOMAC = The Western Ontario and McMaster Universities Osteoarthritis Index.

hemorrhage after TrP-DN, one of which was lost to follow-up because of this adverse effect (Fig. 3). Nevertheless, differences in the adverse effects between groups did not reach statistical significance (P = .073) (Table 1).

### 4.1. Limitations

This study had several limitations. First, the sample size was small, which might have led to type II error. However, according to Mayoral et al,[11] 40 patients would have been sufficient. Second, unlike previous studies,[11] the analgesic medication dose of each patient was not measured. This was because all of our patients were derived from the same postsurgery protocol of the

regional health care system. Third, the Spanish version of the WOMAC was specifically designed for knee osteoarthritis.[23,24] However, several studies with knee postsurgical conditions have used this scale to measure functionality after MTrP-DN.[11,29] Finally, postneedling soreness was not measured, and no interventions were applied to reduce this pain after TrP-DN, except the use of hemostasis.[30]

## 5. Conclusions

In conclusion, quadriceps vastus medialis TrP-DN in conjunction with a rehabilitation protocol in subacute patients with surgical reconstruction of complete ACL rupture increases ROM (short

**Table 3**

Analyses of covariance to determine the influence of LTRs in the outcome measurements of the Rh+TrP-DN group.

| | Effect with LTRs | | Effect without LTRs |
|---|---|---|---|
| | Time | LTRs × time | Time |
| | F (Df); P (Eta$^2$) | F (Df); P (Eta$^2$) | F (Df); P (Eta$^2$) |
| VAS | F (2.72; 51.75)=41.55; P<.001 (0.686) | F (2.72;51.75)=0.52; P=.655 (0.027) | F (2.74; 54.79)=490.09;P<.001 (0.961) |
| WOMAC | F (1.34; 25.50)=69.51; P<.001 (0.785) | F (1.34; 25.50)=0.56; P=.511 (0.029) | F (1.39; 27.72)=848.63; P<.001 (0.977) |
| ROM | F (3.08; 58.46)=37.99; P<.001 (0.667) | F (3.08; 58.46)=0.30; P=.833 (0.015) | F (3.13; 62.62)=439.26; P<.001 (0.956) |
| SEBT | F (1; 19)=104.57; P<.001 (0.846) | F (1; 19)=0.021; P=.886 (0.001) | F (1; 20)=1179.5; P<.001 (0.983) |

Df = degrees of freedom, LTRs = local twitch responses, Rh = rehabilitation protocol, ROM = range of motion, TrP-DN = trigger point dry needling; VAS = visual analogue scale, WOMAC = The Western Ontario and McMaster Universities Osteoarthritis Index.

**Table 4**

Multiple regression analysis to predict a significant effect in the outcome measurements after 24 hours of the intervention.

| | WOMAC | | | | ROM | | | |
|---|---|---|---|---|---|---|---|---|
| Predictor | B (SE) | Beta | t | P | B (SE) | Beta | t | P |
| Sex | −0.73 (1.37) | −0.08 | −0.53 | .599 | 3.93 (3.19) | 0.16 | 1.23 | .225 |
| Age | −0.05 (0.08) | −0.09 | −0.63 | .536 | −0.45 (0.18) | −0.32 | −2.53 | .016 |
| BMI | 0.36 (0.18) | 0.31 | 2.03 | .049 | 0.29 (0.43) | 0.09 | 0.68 | .498 |
| Intervention (Rh) | 3.85 (1.22) | 0.44 | 3.16 | .003 | −14.51 (2.83) | −0.61 | −5.12 | <.001 |
| Surgery type (B-T-B) | 1.80 (1.33) | 0.21 | 1.35 | .185 | 0.29 (3.11) | 0.01 | 0.09 | .926 |
| Constant | 56.46 (5.74) | | 9.83 | < .001 | 110.94 (13.38) | | 8.29 | <.001 |
| Model summary | | | | | | | | |
| Adjusted R$^2$ (%) | | | 24.1 | | | | 44.3 | |
| Model | | | F (5.38)=3.73. P=.008 | | | | F (5.38)=7.84. P<.001 | |
| Assumptions | | | | | | | | |
| Normality | | | P=.268 | | | | P=.652 | |
| Independence | | | 1.83 | | | | 2.03 | |
| Homoscedasticity | | | P=.539 | | | | P=.721 | |

B = regression, BMI = body mass index, B-T-B = patellar bone-tendon-bone graft method, Rh = rehabilitation protocol, ROM = range of motion, SE = standard error, WOMAC = The Western Ontario and McMaster Universities Osteoarthritis Index.

term) and functionality (short- to mid term). Although there was an increase in pain intensity with the addition of TrP-DN, this was not detected beyond immediately after the first treatment. Furthermore, stability does not seem to be modified after TrP-DN.

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