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Ultrasound-guided pulsed radiofrequency versus dry needling in the treatment of myofascial pain: a randomized controlled trial protocol

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Abstract

Introduction: Myofascial pain, especially in the neck and shoulder region, is one of the most common chronic pain disorders worldwide. Dry needling (DN) and pulsed radiofrequency (PRF) are two effective methods for treating myofascial pain. We aim to compare the effects of DN and PRF in neck and shoulder myofascial pain patients.

Methods and analysis: This is a prospective, single-center, randomized, controlled trial in a tertiary hospital. Twenty-two patients aged 18 to 70 years old and diagnosed with myofascial pain in the neck, shoulder, and upper back regions will be recruited and randomly allocated to either DN or PRF group at a 1:1 ratio. DN group will receive ultrasound-guided intramuscular and interfasical dry needling 5 times per pain point and 30 minutes of indwelling. PRF group will receive ultrasound-guided intramuscular (0.9% saline 2ml, 42℃, 2 Hz, 2 minutes) and interfascial (0.9% saline 5ml, 42℃, 2 Hz, 2 minutes) pulsed radiofrequency. Follow-up will be done by the research assistant at postoperative 0, 1, 3, and 6 months. We hypothesize that the postoperative six months pain visual analog score (0-100mm) of the PRF group was at least 20mm lower than that of the DN group. Secondary outcomes include mechanical pain threshold measured by an ergometer, neck disability index (NDI), depression (PHQ-9), anxiety (GAD-7), sleep status (Likert scale), and overall quality of life (SF-36). Between-group comparison will be analyzed using either an independent *t-test* or a nonparametric test based on data normality.

Ethics and dissemination: This study was approved by the Medical Ethics Committee of Peking Union Medical College Hospital (JS-3399). All participants will give written informed consent before data collection. The results from this study will be shared at conferences and disseminated in international journals.

Trial registration: Clinicaltrial.gov (NCT 05637047)

Strengths and limitations of this study

- This is a prospective, randomized, and controlled clinical trial.
- This study will compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in myofascial pain patients, as far as searched, we haven't identified any similar study.
- This study has a 6-month follow-up period, in addition to pain, patients' neck function, depression, anxiety, sleep, and overall quality of life will also be evaluated and reported.
- Findings from the study may provide more evidence to guide clinical practice in myofascial pain patients.
- The study results may not be applied to radiofrequency ablation or dry needling treatment using other different parameters.

Introduction

Background and rationale

Myofascial pain (MPS) is the leading cause of chronic and persistent regional pain, affecting as many as 85% of the general population (1, 2). The neck and shoulder are one of the most commonly involved pain regions and are the leading cause of disability worldwide(3, 4). The exact mechanism of myofascial pain has not been fully illustrated. However, existing studies suggested that muscle overuse or trauma, ergonomic and structural factors, as well as psychological stress, might be potential causes or triggers of this disorder (1).

A variety of treatment methods for myofascial pain have been investigated, including injection of saline, local anesthetics and/or steroids, dry needling, mini-scalpel, rich platelet plasma injection, and radiofrequency ablation. Among these methods, ultrasound-guided dry needling (DN) and pulsed radiofrequency (PRF) of the pain region have been considered two effective and promising treatments for myofascial pain (5, 6).

Dry needling is the insertion of a thin needle into a muscle pain region, which can alleviate muscle spasm-induced pain via increasing endplate discharge and reducing acetylcholine stores (7). Potential mechanisms are considered as the reduction of spontaneous electrical activities, increase of blood flow, release of descending inhibitory neurotransmitters, as well as changes of central and peripheral sensitization(7). Several meta-analysis results supported the use of dry needling, especially deep dry needling, in the management of chronic myofascial pain (6, 8-10). In addition, the use of ultrasonography also further improves procedural safeness and accuracy (5, 11). However, dry needling is not an all-around treatment method. There were still some patients that did not respond well to it (12, 13) and were in request of new therapies.

Pulsed radiofrequency is an important and effective interventional treatment for chronic neuropathic pain disorders. It generates an electromagnetic field in the pain region that acts on several biological pathways, including ion channels, neurotransmitters, postsynaptic receptors, and immune activities (14), thus eliciting a neuromodulation effect (15). Recent studies reported that ultrasound-guided PRF might also be a promising treatment for chronic myofascial pain (16-19). Niraj conducted PRF and steroid injection on twelve abdominal rectus muscle pain patients. At the postoperative six months follow-up, eight patients had 50% pain relief (16). Cho et al compared the analgesic effects of inter-fascial PRF (42°C, 5Hz, 55V) and local anesthetic (0.6% lidocaine 10ml) injection in trapezius and rhomboid muscle pain patients. The pain visual analog score (VAS)

of the PRF group was lower than that of the local anesthetic injection group at postoperative 4 and 8 weeks (19). Park et al conducted a study similar to Cho et al's on gastrocnemius and soleus muscle pain patients, which resulted in similar conclusions (20). However, both studies performed treatment only once and followed the patients for only two months. Myofascial pain always requires multiple sessions of continuous treatment and long-term management (21). Also, we failed to identify any study comparing the effects of DN and PRF in myofascial pain patients as far as searched.

Objectives

This study aims to compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in myofascial pain patients. We hypothesize that at postoperative six months follow-up, the pain VAS of patients undergoing PRF is lower than that of patients undergoing DN, and the differences in pain VAS between PRF and DN groups are of clinical significance.

Methods and analysis

Trial design and study setting

This is a randomized, controlled trial that will be conducted at the Peking Union Medical College Hospital, in Beijing, China. The proposed trial was designed by following the SPIRIT guidelines. We will conduct it in accordance with the guidelines of the Consolidated Standards of Reporting Trials (CONSORT).

Eligible criteria

Participants must meet all the following criteria for inclusion:

1. Aged between 18 to 70 years old.
2. Chronic myofascial pain lasting more than three months at the neck, shoulder, and upper back region (22).
3. Have at least a score of "moderate" on the pain VAS, thus a minimal clinically significant change is detectable (23).

Participants must meet at least one of the following criteria for exclusion:

1. Currently undergoing other pain-related treatments (acupuncture, laser, infrared therapy. etc).
2. Presence or history of trauma, surgery, or infection in the pain region.
3. Severe systemic disease (eg. severe hepatic or renal dysfunction), coagulopathy, or on medications affecting the coagulation system.
4. Allergic to medications used.
5. Pregnant, medical background, unable to cooperate, or refused to participate.

Participants who meet the following criteria will be withdrawn from the study.

1. Unwilling to continue participation or unable to follow the treatment plan.
2. Unable to obtain the primary outcome data due to any reason.

Interventions

The workflow of this trial is described in Figure 1. Patients from the pain clinics of the study hospital will be screened for eligibility. After obtaining informed consent, all participants will complete the baseline assessment form and be randomized to either DN or PRF group before treatment.

Pretreatment assessment

Baseline assessment including participants' demographics, clinical data, and questionnaire answers will be collected using a digital healthcare system. Demographic data include age, sex, body mass index, occupation, and educational level. Clinical data includes sites, duration, and characteristics of pain, the mechanical pain threshold of the pain region measured by an ergometer, pain degree measured by VAS, neck disability index, depression measured by patient health questionnaire (PHQ-9) scale, anxiety measured by generalized anxiety disorder (GAD-7) scale, sleep status measured by Likert scale and overall quality of life measured by health-related quality of life questionnaire (SF-36).

Prepare

The whole procedure will be performed in a standard operating room. Patients will be lying in the prone position with vital signs monitored. After marking the pain region with "×------×", patients will be sterilized and draped using a standard fashion, thus the whole procedure can only be felt but not be seen by the patient. Both interventions will be performed under real-time ultrasound guidance (Sonosite X-port, USA) with the transducer covered by sterilized protective bags.

Pulsed radiofrequency

After using ultrasound to identify the muscle and fascia of the pain region, a radiofrequency cannula (20G, Inomed Corp, German) will be inserted under real-time ultrasound guidance. Intramuscular PRF will be performed after injecting 2ml of 0.9% saline into the muscle, using the following parameters: 42℃, 2 Hz, 2 minutes. Inter-fascial PRF will be performed after injecting 5ml of 0.9% saline between two layers of fascia, using the following parameters: 42℃, 2Hz, 6 minutes (R-2000B A1 Beiqi Corp, China). After PRF, the cannula will be extracted and the wound will be covered with sterilized cotton.

Dry needling

After using ultrasound to identify the muscle and fascia of the pain region, a thin acupuncture needle (0.03mm, 60-100mm, Chengzhen Corp, China) will be inserted under real-time ultrasound guidance. Dry needling will be performed 5 times per pain point and extracted after 30 minutes of indwelling (21).

Follow up

Both PRF and DN will be repeated every week for a total of four times. Follow-up will be completed during an outpatient visit by an experienced clinician blinds to group allocation at 0, 1, 3, and 6 months after the entire treatment program ends.

Outcomes

The primary outcome is patients' pain VAS at postoperative six-month follow-up. The pain VAS measures pain intensity on a line of 100mm, with 0mm indicating no pain, and 100mm indicating the worst imaginable pain. Changes of 20mm or more are considered of clinical significance (23).

Secondary outcomes include mechanical pain threshold measured by an ergometer, depression measured by patient health questionnaire (PHQ-9), anxiety measured by generalized anxiety disorder (GAD-7) scale, neck disability index (NDI) scale, sleep quality measured by Likert scale and overall quality of life measured by health-related quality of life (SF-36) scale. All scales provided to participants will be corresponding validated Chinese versions (24-26).

Participant timeline

The participant timeline was listed in Table 1. The recruitment and baseline assessment will last one week. The intervention period will last 4 weeks, starting after the baseline assessment. The follow-up period will last six months, starting at the end of the intervention period. Patients will be asked to measure mechanical pain threshold and fill questionnaires during follow-up visits at 0, 1, 3, and 6 months after the intervention period.

Table 1. Schedule of enrollment, interventions, and assessments.

	Enrollment	Baseline	Intervention				Follow up			
Timeline	$-t_1$	0	t_{11}	t_{12}	t_{13}	t_{14}	t_{21}	t_{22}	t_{23}	t_{24}
Enrollment	×									
Eligibility screen	×									
Informed consent	×									
Baseline assessment		×								
Randomization		×								
Allocation		×								
Interventions										
DN			×	×	×	×				
PRF			×	×	×	×				
Assessments										
Pain VAS		×					×	×	×	×
Pain threshold		×					×	×	×	×
NDI		×					×	×	×	×
PHQ-9		×					×	×	×	×
GAD-7		×					×	×	×	×
Sleep Likert scale		×					×	×	×	×
SF-36		×					×	×	×	×

$-t_1$=pre-intervention; 0=baseline assessment; t_{11}-t_{14}: intervention; t_{21}-t_{24}: follow up

Sample size and statistical analysis

The sample size was calculated based on the hypothesis that the pain VAS of the PRF group is 20mm lower than that of the DN group, which was considered clinically significant (23). According to a previous study, the pain VAS after DN treatment was (38±15)mm (5). Assuming an α of 0.05 and β of 0.8, ten patients will be needed in each group to detect a 20mm difference in pain VAS. Accounting for a 10% dropout rate, a total of twenty-two patients will be recruited.

Recruitment

All patients visiting the pain clinics of the study hospital can be invited by clinicians to participate in this trial. These patients will be informed of the trial by the clinicians. If a patient intends to participate, the research team will be contacted to provide further information on the trial. If a patient confirms participation, eligibility will be checked and the informed consent will be signed. After completion of the baseline assessment, randomization will be performed by a research member and the clinician responsible for the patient's treatment will be informed of the randomization result.

Allocation

Participants will be randomly allocated to either PRF or DN groups at a 1:1 ratio based on a computer-generated randomization result. One experienced clinician will perform either PRF or DN treatments on all participants based on their group allocation results.

Blinding

The pain clinician responsible for pain interventional treatment will not be blinded to group allocation. The researchers responsible for postoperative follow-up and statistical analysis will be blinded to group allocation. The pain clinician will try his/her best to blind the patients as much as possible during treatment. For instance, a patient will be asked to lie in the prone position and covered with sterilized drapes so that the whole treatment procedure can only be felt but not be seen by the patient. A research assistant will broadcast the sound of PRF during DN treatment to simulate similar scenarios.

Data collection

After signing informed consent, a dedicated research member will guide the participants in completing the baseline assessment. Subsequently, the participants will be randomized to one of the two intervention groups. Participants will be asked to complete follow-up assessments during outpatient clinic re-visits at 0, 1, 3, and 6

months after completion of the entire treatment program. If a participant does not show up during the re-visit, a telephone call will be made to remind the participant.

Data management

Data will be managed using a digital healthcare system. A unique code will be allocated to each participant and recorded on trial documents, except for informed consent and contact details. The identifiable data of each participant will be stored separately and securely from other study data.

Statistical methods

The study results will be analyzed using SPSS 23. Normality will be tested with a Q-Q plot. Continuous variables with a normal distribution will be expressed as mean ± standard deviation, continuous variables with a non-normal distribution will be expressed as medians (quartile), and categorical variables will be expressed as case numbers (percentages). An independent t-test will be used to analyze the continuous variables with a normal distribution. The Mann-Whitney *U* test will be performed for the analysis of the continuous variables with a non-normal distribution. The chi-square test will be used to evaluate categorical data when the expected cell counts are > 5; otherwise, Fisher's exact test will be used.

Data monitoring and auditing

Data monitoring will be performed once per year by independent monitors. No Data Monitoring Committee will be assigned to this study. Trial conduct and data integrity will also be audited once a year by independent auditors.

Harms

Adverse events will be reported by participant self-report questionnaires. The pain clinicians responsible for patient treatment will be asked to report serious adverse events to the research team. The research team will report these adverse events to the Ethics Committee.

Patient and public involvement

Before study design, myofascial pain patients who recently visited the hospital pain clinics were contacted to participate in the research patient panel and provide opinions on the research question, outcome measures, burden of intervention, as well as their experiences and preferences. These patients can comment on the study design and help disseminate the final results, but they will not be involved in the recruitment or conduct of the study.

Ethics and dissemination

This study was approved by the ethics committee of Peking Union Medical College Hospital (JS-3399), was registered at Clinicaltrials.gov (NCT 05637047,) and will adhere to the Declaration of Helsinki. Detailed information about the trial will be given to all participants before signing informed consent, which will be requested before participation. Participants have the right to withdraw from the study at any time. If the study protocol needs to be changed, a research team will inform the participants and clinicians. Study results will be disseminated at medical conferences, and we also intend to publish our findings in an international journal.

Contributorship statement

WJ and CXL designed the study, WJ drafted the manuscript, and CXL revised the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Full References

1. Galasso A, Urits I, An D, Nguyen D, Borchart M, Yazdi C, et al. A Comprehensive Review of the Treatment and Management of Myofascial Pain Syndrome. Curr Pain Headache Rep. 2020;24(8):43.

2. Li X, Wang R, Xing X, Shi X, Tian J, Zhang J, et al. Acupuncture for Myofascial Pain Syndrome: A Network Meta-Analysis of 33 Randomized Controlled Trials. Pain Physician. 2017;20(6):E883-e902.

3. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1545-602.

4. Heredia-Rizo AM, Petersen KK, Madeleine P, Arendt-Nielsen L. Clinical Outcomes and Central Pain Mechanisms are Improved After Upper Trapezius Eccentric Training in Female Computer Users With Chronic Neck/Shoulder Pain. Clin J Pain. 2019;35(1):65-76.

5. Diep D, Chen KJQ, Kumbhare D. Ultrasound-guided interventional procedures for myofascial trigger points: a systematic review. Reg Anesth Pain Med. 2021;46(1):73-80.

6. Cerezo-Téllez E, Torres-Lacomba M, Fuentes-Gallardo I, Perez-Muñoz M, Mayoral-Del-Moral O, Lluch-Girbés E, et al. Effectiveness of dry needling for chronic nonspecific neck pain: a randomized, single-blinded, clinical trial. Pain. 2016;157(9):1905-17.

7. Cagnie B, Dewitte V, Barbe T, Timmermans F, Delrue N, Meeus M. Physiologic effects of dry needling. Curr Pain Headache Rep. 2013;17(8):348.

8. Cagnie B, Castelein B, Pollie F, Steelant L, Verhoeyen H, Cools A. Evidence for the Use of Ischemic Compression and Dry Needling in the Management of Trigger Points of the Upper Trapezius in Patients with Neck Pain: A Systematic Review. Am J Phys Med Rehabil. 2015;94(7):573-83.

9. Trinh K, Graham N, Irnich D, Cameron ID, Forget M. Acupuncture for neck disorders. Cochrane Database Syst Rev. 2016(5):Cd004870.

10. Liu L, Huang QM, Liu QG, Ye G, Bo CZ, Chen MJ, et al. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2015;96(5):944-55.

11. Kumbhare D, Singh D, Rathbone HA, Gunn M, Grosman-Rimon L, Vadasz B, et al. Ultrasound-Guided Interventional Procedures: Myofascial Trigger Points With Structured Literature Review. Reg Anesth Pain Med. 2017;42(3):407-12.

12. Gattie E, Cleland JA, Snodgrass S. The Effectiveness of Trigger Point Dry Needling for Musculoskeletal Conditions by Physical Therapists: A Systematic Review and Meta-analysis. J Orthop Sports Phys Ther. 2017;47(3):133-49.

13. Hall ML, Mackie AC, Ribeiro DC. Effects of dry needling trigger point therapy in the shoulder region on patients with upper extremity pain and dysfunction: a systematic review with meta-analysis. Physiotherapy. 2018;104(2):167-77.

14. Sam J, Catapano M, Sahni S, Ma F, Abd-Elsayed A, Visnjevac O. Pulsed Radiofrequency in Interventional Pain Management: Cellular and Molecular Mechanisms of Action - An Update and Review. Pain Physician. 2021;24(8):525-32.

15. Jorge DMF, Huber SC, Rodrigues BL, Da Fonseca LF, Azzini GOM, Parada CA, et al. The Mechanism of Action between Pulsed Radiofrequency and Orthobiologics: Is There a Synergistic Effect? Int J Mol Sci. 2022;23(19).

16. Niraj G. Ultrasound-guided pulsed radiofrequency treatment of myofascial pain syndrome: a case series. Br J Anaesth. 2012;109(4):645-6.

17. Tamimi MA, McCeney MH, Krutsch J. A case series of pulsed radiofrequency treatment of myofascial trigger points and scar neuromas. Pain Med. 2009;10(6):1140-3.

18. Park CH, Lee YW, Kim YC, Moon JH, Choi JB. Treatment experience of pulsed radiofrequency under ultrasound guided to the trapezius muscle at myofascial pain syndrome -a case report. Korean J Pain. 2012;25(1):52-4.

19. Cho IT, Cho YW, Kwak SG, Chang MC. Comparison between ultrasound-guided interfascial pulsed radiofrequency and ultrasound-guided interfascial block with local anesthetic in myofascial pain syndrome of trapezius muscle. Medicine (Baltimore). 2017;96(5):e6019.

20. Park SM, Cho YW, Ahn SH, Lee DG, Cho HK, Kim SY. Comparison of the Effects of Ultrasound-Guided Interfascial Pulsed Radiofrequency and Ultrasound-Guided Interfascial Injection on Myofascial Pain Syndrome of the Gastrocnemius. Ann Rehabil Med. 2016;40(5):885-92.

21. Liu L, Huang QM, Liu QG, Thitham N, Li LH, Ma YT, et al. Evidence for Dry Needling in the Management of Myofascial Trigger Points Associated With Low Back Pain: A Systematic Review and Meta-Analysis. Arch Phys Med Rehabil. 2018;99(1):144-52.e2.

22. Simons DG TJ, Simons LS. Myofascial pain and dysfunction. The trigger point manual. Upper Half of Body Baltimore: Williams & Wilkins; 1999.

23. Farrar JT, Portenoy RK, Berlin JA, Kinman JL, Strom BL. Defining the clinically important difference in pain outcome measures. Pain. 2000;88(3):287-94.

24. Lim HHR, Tang ZY, Hashim M, Yang M, Koh EYL, Koh KH. Cross-cultural Adaptation, Reliability, Validity, and Responsiveness of the Simplified-Chinese Version of Neck Disability Index. Spine (Phila Pa 1976). 2020;45(8):541-8.

25. Wang W, Bian Q, Zhao Y, Li X, Wang W, Du J, et al. Reliability and validity of the Chinese version of the Patient Health Questionnaire (PHQ-9) in the general population. Gen Hosp Psychiatry. 2014;36(5):539-44.

26. Yu J, Coons SJ, Draugalis JR, Ren XS, Hays RD. Equivalence of Chinese and US-English versions of the SF-36 health survey. Qual Life Res. 2003;12(4):449-57.

Figure legends

Figure 1. Flowchart of the study protocol.

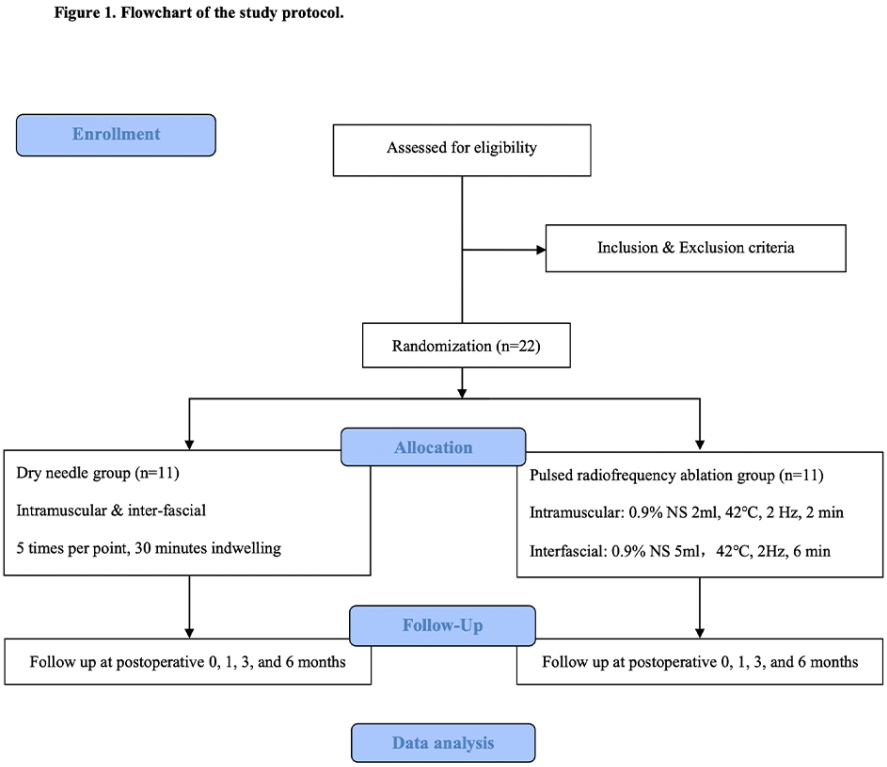

Figure 1: Flowchart of the study protocol.

90x90mm (300 x 300 DPI)

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Ultrasound-guided pulsed radiofrequency versus dry needling for pain management in chronic neck and shoulder myofascial pain patients: A randomized controlled trial protocol

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Abstract

Introduction: Myofascial pain, especially in the neck and shoulder region, is one of the most common chronic pain disorders worldwide. Dry needling (DN) and pulsed radiofrequency (PRF) are two effective methods for treating myofascial pain. We aimed to compare the effects of DN and PRF in chronic neck and shoulder myofascial pain patients.

Methods and analysis: This is a prospective, single-center, randomized, controlled trial in a tertiary hospital. We plan to recruit 108 patients aged 18 to 70 years old who are diagnosed with chronic myofascial pain in the neck, shoulder, and upper back regions and randomly allocate them to either the DN or PRF group at a 1:1 ratio. The DN group will receive ultrasound-guided intramuscular and interfascial dry needling 8-10 times per pain point or until local twitch responses are no longer elicited, and 30 minutes of indwelling. The PRF group will receive ultrasound-guided intramuscular (0.9% saline 2 ml, 42℃, 2 Hz, 2 minutes) and interfascial (0.9% saline 5 ml, 42℃, 2 Hz, 2 minutes) pulsed radiofrequency. Follow-up will be performed by the research assistant at 0, 1, 3, and 6 months postoperatively. The primary outcome is the postoperative six-month pain visual analog score (0-100 mm). Secondary outcomes include pressure pain threshold measured by an algometer, neck disability index (NDI), depression (PHQ-9), anxiety (GAD-7), sleep status (Likert scale), and overall quality of life (SF-36). Between-group comparisons will be analyzed using either a nonparametric test or a mixed-effects linear model.

Ethics and dissemination: This study was approved by the Medical Ethics Committee of Peking Union Medical College Hospital (JS-3399). All participants will give written informed consent before participation. The results from this study will be shared at conferences and disseminated in international journals.

Strengths and limitations of this study

- This is a prospective, randomized, and controlled clinical trial.
- This study will compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in myofascial pain patients. To the best of our knowledge, we have not identified any similar study.
- This study has a 6-month follow-up period. In addition to pain, patients' neck function, depression, anxiety, sleep, and overall quality of life will also be evaluated and reported.
- Findings from the study may provide more evidence to guide clinical practice in myofascial pain patients.
- The study results may not be applicable to radiofrequency ablation or dry needling treatment using other parameters.

Introduction

Background and rationale

Myofascial pain (MPS) is the leading cause of chronic and persistent regional pain, affecting as many as 85% of the general population [1 2]. The neck and shoulder are some of the most commonly involved pain regions and are the leading causes of disability worldwide[3 4]. The exact mechanism of myofascial pain has not been fully illustrated. However, existing studies have suggested that muscle overuse or trauma, ergonomic and structural factors, and psychological stress might be potential causes or triggers of this disorder [1].

A variety of treatment methods for myofascial pain have been investigated, including injection of saline, local anesthetics and/or steroids, dry needling, mini-scalpel, rich platelet plasma injection, and pulsed radiofrequency. Among these methods, ultrasound-guided dry needling (DN) and pulsed radiofrequency (PRF) of the pain region have been considered two effective and promising treatments for myofascial pain [5 6].

Dry needling is the insertion of a thin needle into a muscle pain region to alleviate pain. The exact analgesic mechanisms have not been unraveled, but it is hypothesized that DN may increase endplate discharge and local blood flow, reduce spontaneous electrical activities and acetylcholine stores, and change the release of descending inhibitory neurotransmitters as well as the central and peripheral sensitization process [7-9]. Tellez et al.'s study on 130 nonspecific neck pain patients showed that dry needling can effectively reduce pain intensity, mechanical hyperalgesia, neck active angle of motion and muscle strength at 1, 3 and 6 months postoperatively [6]. Several meta-analysis results also supported the use of dry needling, especially deep dry needling, in the management of chronic myofascial pain [10-12]. Cagnie et al. reviewed fifteen randomized controlled trials including approximately 800 patients and concluded that there was strong evidence for dry needling to have a positive effect on pain intensity[10]. In addition, the use of ultrasonography further improves procedural safety and accuracy [5 13]. However, dry needling is not an all-around treatment method. There were still some patients who did not respond well to it [14 15] and were in request of new therapies.

Pulsed radiofrequency is an important and effective interventional treatment for chronic neuropathic pain disorders. It generates an electromagnetic field in the pain region that acts on several biological pathways, including ion channels, neurotransmitters, postsynaptic receptors, and immune activities [16], thus eliciting a neuromodulation effect [17]. Recent studies have reported that ultrasound-guided PRF might also be a promising

treatment for chronic myofascial pain [18-21]. Niraj administered PRF and steroid injections to twelve patients with abdominal rectus muscle pain. At the six-month postoperative follow-up, eight patients had 50% pain relief [18]. Cho et al. compared the analgesic effects of interfascial PRF (42 °C, 5 Hz, 55 V) and local anesthetic (0.6% lidocaine 10 ml) injection in trapezius and rhomboid muscle pain patients, and the results showed that the pain visual analog score (VAS) of the PRF group was lower than that of the local anesthetic injection group at 4 and 8 weeks postoperatively [21]. Park et al. compared the analgesic effects of interfascial PRF and local anesthetic injection on gastrocnemius and soleus muscle pain patients, and the results showed that the pain intensity and physical and mental component summary scores were better in the PRF group than in the injection group [22]. However, both studies performed treatment only once and followed the patients for only two months. Myofascial pain always requires multiple sessions of continuous treatment and long-term management [23]. To date, there are currently a lack of high-quality studies on the treatment effects of PRF in myofascial pain patients, and it is also unknown whether PRF can exhibit a superior analgesic effect to DN. Since placebo/sham comparison of each individual intervention provides only limited information, we decided to design a parallel study comparing the two interventions together.

Objectives

This study aims to compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in chronic myofascial pain patients. We hypothesized that at the six-month postoperative follow-up, the pain VAS of patients undergoing PRF would be lower than that of patients undergoing DN, and the differences in pain VAS between the PRF and DN groups would be statistically significant.

Methods and analysis

Trial design and study setting

This is a parallel, randomized, equivalence trial that will be conducted at the Peking Union Medical College Hospital in Beijing, China. The proposed trial was designed by following the SPIRIT guidelines (supplement file 1) and approved by the institutional review board (JS-3399). We will report it in accordance with the guidelines of the Consolidated Standards of Reporting Trials (CONSORT). The planned start and end dates of the study are September 1, 2023, and June 1, 2025, respectively.

Eligible criteria

Participants must meet all the following criteria for inclusion:

1. Aged between 18 and 70 years old.
2. Chronic (>3 months) myofascial pain in the neck, shoulder, and upper back region.
3. Myofascial pain will be diagnosed based on Simons and Travell's criteria: taut band palpable, exquisite spot tenderness of a nodule in a taut band, patient's recognition of current pain complaint by pressure on the tender nodule, and painful limit to full stretch range of motion[6 24].
4. Have at least a pain VAS score of 40 mm; thus, a minimal clinically significant change is detectable [25].

Participants must meet at least one of the following criteria for exclusion:

1. History of receiving DN or PRF treatment or currently undergoing other pain-related treatments (acupuncture, laser, infrared therapy, etc.).
2. Presence or history of trauma, surgery, or infection in the pain region.
3. Current or history of taking moderate to strong analgesics, such as tramadol and morphine.
4. Severe systemic disease (eg. severe hepatic or renal dysfunction), coagulopathy, or medications affecting the coagulation system.
5. Allergy to medications used.
6. Pregnancy, psychiatric disease, medical background, inability to cooperate, or refusal to participate.

Participants who meet the following criteria will be withdrawn from the study.

1. Unwilling to continue participation or unable to follow the treatment plan.

2. Unable to obtain the primary outcome data due to any reason.

Interventions

The workflow of this trial is described in Figure 1. Patients from the pain clinics of the study hospital will be screened for eligibility. After obtaining informed consent, all participants will complete the baseline assessment form and be randomized to either the DN or PRF group before treatment.

Pretreatment assessment

Baseline assessments, including participants' demographics, clinical data, and questionnaire answers, will be collected using a digital health care system. Demographic data included age, sex, body mass index (BMI), occupation, and educational level. Clinical data included sites, duration, and characteristics of pain, pain degree measured by VAS, neck disability index, depression measured by the patient health questionnaire (PHQ-9) scale, anxiety measured by the generalized anxiety disorder (GAD-7) scale, sleep status measured by the Likert scale and overall quality of life measured by the health-related quality of life questionnaire (SF-36).

Prepare

The whole procedure will be performed in a standard operating room with qualified disinfection and surgical kits, an ultrasound machine (Sonosite X-port, USA) and a pulsed radiofrequency machine (R-2000B A1 Beiqi Corp, China). A certified pain clinician with three years of fellowship training and five years of independent clinical practice experience will provide treatment for all participants with assistance from a pain nurse with more than ten years of nursing experience.

After putting the patient in the prone position on the operating table with vital signs monitored, the pain clinician will palpate the patient and mark the pain regions with "×------×". The pressure pain threshold will be measured at the center of the marked pain region using an algometer with a probe area of 1 cm^2. The algometer will be applied perpendicular to the tissue at a constant rate of approximately 30 kPa/s. A 30-second resting period will be allowed between each measure to avoid temporal summation, and the average of three trials will

be calculated and recorded as the final results. Then, patients will be sterilized and draped using a standard fashion; thus, the whole procedure can only be felt but not seen by the patient.

Both interventions will be performed under real-time ultrasound guidance (Sonosite X-port, USA) with the transducer covered by sterilized protective bags. A linear transducer will be placed on the marked pain region to identify the musculoskeletal structures, including the superficial and deep muscle layers, as well as the fascia. The ultrasound parameters will be set as follows: linear transducer 4-13 Hz, MSK general mode, target depth 3-5 cm, medium brightness.

Pulsed radiofrequency

After using ultrasound to identify the muscle and fascia of the pain region, a radiofrequency cannula (20G, Inomed Corp, German) will be inserted into the previously marked pain region under real-time ultrasound guidance. PRF will be performed both in the superficial (trapezius muscle, supraspinatus muscle) and deep (splenius capitis, rhomboid muscle, levator scapulae) muscle layers, as well as in the fascia between the two layers. Intramuscular PRF will be performed after injecting 2 ml of 0.9% saline into the muscle using the following parameters: 42 °C, 2 Hz, 2 minutes. Interfascial PRF will be performed after injecting 5 ml of 0.9% saline into the fascia layers using the following parameters: 42 °C, 2 Hz, 6 minutes. After PRF, the cannula will be extracted, and the wound will be covered with sterilized cotton.

Dry needling

After using ultrasound to identify the muscle and fascia of the pain region, a thin acupuncture needle (0.03 mm, 60-100 mm, Chengzhen Corp, China) will be inserted into the previously marked pain region under real-time ultrasound guidance. Then, rapid insertion of the needle in and out of the pain point will be performed in a way similar to Hong's fast-in and fast-out technique[26]. Based on previous study experiences, dry needling will be performed either until local twitch responses are no longer elicited or 8 to 10 times per pain point and indwelled for 30 minutes [23 27 28]. Then, the needle will be extracted, and hemostatic compression will be applied on the needled muscle.

Follow-up

Both PRF and DN will be repeated every week for a total of four times. Follow-up will be completed during an outpatient visit by an experienced clinician blinded to group allocation at 0, 1, 3, and 6 months after cessation of the treatment program.

Outcomes

The primary outcome is patients' pain VAS at the six-month postoperative follow-up. The pain VAS measures pain intensity on a line of 100 mm, with 0 mm indicating no pain and 100 mm indicating the worst imaginable pain [25].

Secondary outcomes include pressure pain threshold measured by an algometer, depression measured by the patient health questionnaire (PHQ-9), anxiety measured by the generalized anxiety disorder (GAD-7) scale, neck disability index (NDI) scale, sleep quality measured by the Likert scale and overall quality of life measured by the health-related quality of life (SF-36) scale. All scales provided to participants will be corresponding validated Chinese versions [29-31].

Participant timeline

The participant timeline is listed in Table 1. The recruitment and baseline assessment will last one week. The intervention period will last 4 weeks, starting after the baseline assessment. The follow-up period will last six months, starting at the end of the intervention period. Patients will be asked to measure the pressure pain threshold and complete questionnaires during follow-up visits at 0, 1, 3, and 6 months after the intervention period.

Table 1. Schedule of enrollment, interventions, and assessments.

	Enrollment	Baseline	Intervention				Follow up			
Timeline	$-t_1$	0	t_{11}	t_{12}	t_{13}	t_{14}	t_{21}	t_{22}	t_{23}	t_{24}
Enrollment	×									
Eligibility screen	×									

Informed consent	×									
Baseline assessment		×								
Randomization		×								
Allocation		×								
Interventions										
DN			×	×	×	×				
PRF			×	×	×	×				
Assessments										
Pain VAS		×					×	×	×	×
Pain threshold		×					×	×	×	×
NDI		×					×	×	×	×
PHQ-9		×					×	×	×	×
GAD-7		×					×	×	×	×
Sleep Likert scale		×					×	×	×	×
SF-36		×					×	×	×	×

t_1=pre-intervention; 0=baseline assessment; t_{11}-t_{14}: intervention; t_{21}-t_{24}: follow-up

Sample size

The sample size was calculated based on a null hypothesis of the primary outcome, pain VAS at six months postoperatively. According to prior study and our pilot study experiences, the pain VAS after DN and PRF treatment was (38±15) mm and (26±18) mm, respectively [5]. Assuming an α of 0.05 and β of 0.9, forty-two patients will be needed in each group to detect significant differences. Accounting for a 20% dropout rate, a total of 108 patients will be recruited.

Recruitment

All patients visiting the pain clinics of the study hospital can be invited by clinicians to participate in this trial. These patients will be informed of the trial by the clinicians. If a patient intends to participate, the

research team will be contacted to provide further information on the trial. If a patient confirms participation, eligibility will be checked, and informed consent will be signed. After completion of the baseline assessment, randomization will be performed by a research member, and the clinician responsible for the patient's treatment will be informed of the randomization result.

Allocation

Participants will be randomly allocated to either PRF or DN groups at a 1:1 ratio by a research member based on a computer-generated randomization result. According to a pregenerated random sequence, each enrolled patient will be given a sealed opaque envelope based on the order of enrollment. After the patient has been sterilized, a pain nurse will open the sealed envelope and assign the patient to the corresponding group according to the random number in the envelope, and an experienced clinician will perform the corresponding treatment on the patient.

Blinding

The clinician responsible for participants' treatment will not be blinded to group allocation. The researchers responsible for postoperative follow-up and statistical analysis will be blinded to group allocation. The pain clinician will try his or her best to blind the patients as much as possible during treatment. For instance, a patient will be asked to lie in the prone position and covered with sterilized drapes so that the whole treatment procedure can only be felt but not seen by the patient. A research assistant will broadcast the sound of PRF during DN treatment to simulate similar scenarios. The adequacy of blinding will be tested after completion of the treatment by asking the participants to guess whether they received DN or PRF. The questionnaire will have seven choices: certainly DN, certainly PRF, probably DN, probably PRF, possibly DN, possibly PRF, and do not know. Unblinding will be carried out after completion of the statistical analysis. Participants who select "certainly", "probably", "possibly" and are correct about the answer are considered correct.

Data collection

After signing informed consent, a dedicated research member will guide the participants in completing the baseline assessment. Subsequently, the participants will be randomized to one of the two intervention groups. Participants will be asked to complete follow-up assessments during outpatient clinic revisits at 0, 1, 3, and 6 months after completion of the entire treatment program. If a participant does not show up during the revisit, a telephone call will be made to remind the participant. All questionnaires can also be sent as online links to participants via short messages.

Data management

Data will be managed using a digital health care system. A unique code will be allocated to each participant and recorded on trial documents, except for informed consent and contact details. The identifiable data of each participant will be stored separately and securely from other study data.

Statistical methods

Statistical analysis will follow the intention-to-treat principle. Based on previous studies and our clinical experiences, the postoperative six-month pain VAS will have a highly skewed distribution; hence, the primary outcome, the postoperative six-month pain VAS, will be analyzed using the Mann–Whitney U test. Median difference with 95% confidence interval will be reported as effect size using Hodges–Lehmann's method. Secondary outcomes, including pain, psychological, sleep and life quality scale scores at different postoperative time points, will be analyzed using the mixed-effects linear model, in which the outcome measure will be regressed against the fixed-effect group allocation, categorial time points, and interaction between group allocation and time. A random-effects intercept will be included in the model without any random-effects slope, and autoaggressive 1 will be used as the covariance structure. The marginal group difference with a 95% confidence interval estimated by the mixed-effects model will be used as the effect size for secondary outcomes.

If missing data occurred in the primary outcome, the last observation carried forward method was used for data imputation. A complete case dataset without any imputation will be used in the secondary outcomes. No adjustment for multiplicity will be conducted among different secondary outcomes; hence, relevant findings

will be interpreted only as exploratory results. Data analysis will be conducted in Statistical Package for the Social Sciences (SPSS, Chicago, Illinois, USA) version 23.0. A two-sided *P* value less than 0.05 was regarded as statistically significant.

Data monitoring and auditing

Data monitoring will be performed once per year by independent monitors. No Data Monitoring Committee will be assigned to this study since the risks of interventions are relatively low and the study period is short. Trial conduct and data integrity will also be audited once a year by independent auditors. We plan to perform an interim analysis after half of the patients are included. The sponsors and researchers will have access to these interim results and make the final decision of whether to continue or terminate the trial.

Harms

Adverse events will be reported by participant self-report questionnaires. The pain clinicians responsible for patient treatment will be asked to report serious adverse events to the research team. The research team will report these adverse events to the Ethics Committee.

Patient and public involvement

Before study design, myofascial pain patients who recently visited the hospital pain clinics were contacted to participate in the research patient panel and provide opinions on the research question, outcome measures, burden of intervention, as well as their experiences and preferences. These patients can comment on the study design and help disseminate the final results, but they will not be involved in the recruitment or conduct of the study.

Ethics and dissemination

This study was approved by the ethics committee of Peking Union Medical College Hospital (JS-3399), was registered at Clinicaltrials.gov (NCT 05637047) and will adhere to the Declaration of Helsinki. Protocol modifications will require a formal amendment to the protocol with agreement from the project management committee (WJ, ZYL, CXL) and updates in the trial registry (Clinicaltrials.gov). Then, a research member will inform the participants. Participants have the right to withdraw from the study at any time. The researchers can also discontinue treatment for a participant's best interest (eg. severe adverse events). All changes in the participant's intervention will be recorded in detail in the case report form. All participants will be given detailed information about the trial by a research member, and reflection time will be given before signing informed consent (supplement file 2), which will be requested before participation. Participant confidentiality will be ensured according to laws and regulations. Participants' data will be maintained in secure storage at the coordinating center for 5 years after completion of the study.

The primary data can be accessed by a dedicated research member during data collection. After the final dataset is formed from the primary data, dataset access will be limited to statisticians and all authors of the final publication. Patients will be treated during the trial with the best intention. There will be no ancillary or posttrial care. Participants will not receive any compensation from the harm of the treatment beyond the compensation from the National Medicare System if malpractice has taken place. Study results will be disseminated at medical conferences, and we also intend to publish our findings in an international journal. Substantial contributions to the conception or design of the study; acquisition, analysis or interpretation of data; draft or revision of the manuscript will be warranted as author. No professional writers will be invited.

Figure legends

Figure 1. Flowchart of the study protocol.

LTR: local twitch response

Contributorship statement

WJ and CXL designed the study, ZYL revised the statistical design, WJ and ZYL drafted the manuscript, and CXL revised the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Bethune Charitable Foundation and Peking Union Medical College Hospital are sponsors. They will only be involved in providing financial support for study conduction and will not affect the results of the trial.

Full References

1. Galasso A, Urits I, An D, et al. A Comprehensive Review of the Treatment and Management of Myofascial Pain Syndrome. *Curr Pain Headache Rep* 2020;24(8):43. doi: 10.1007/s11916-020-00877-5 [published Online First: 2020/07/01]
2. Li X, Wang R, Xing X, et al. Acupuncture for Myofascial Pain Syndrome: A Network Meta-Analysis of 33 Randomized Controlled Trials. *Pain Physician* 2017;20(6):E883-e902. [published Online First: 2017/09/22]
3. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1545-602. doi: 10.1016/s0140-6736(16)31678-6 [published Online First: 2016/10/14]
4. Heredia-Rizo AM, Petersen KK, Madeleine P, et al. Clinical Outcomes and Central Pain Mechanisms are Improved After Upper Trapezius Eccentric Training in Female Computer Users With Chronic Neck/Shoulder Pain. *Clin J Pain* 2019;35(1):65-76. doi: 10.1097/ajp.0000000000000656 [published Online First: 2018/09/18]
5. Diep D, Chen KJQ, Kumbhare D. Ultrasound-guided interventional procedures for myofascial trigger points: a systematic review. *Reg Anesth Pain Med* 2021;46(1):73-80. doi: 10.1136/rapm-2020-101898 [published Online First: 2020/11/08]
6. Cerezo-Téllez E, Torres-Lacomba M, Fuentes-Gallardo I, et al. Effectiveness of dry needling for chronic nonspecific neck pain: a randomized, single-blinded, clinical trial. *Pain* 2016;157(9):1905-17. doi: 10.1097/j.pain.0000000000000591 [published Online First: 2016/08/19]
7. Chen JT, Chung KC, Hou CR, et al. Inhibitory effect of dry needling on the spontaneous electrical activity recorded from myofascial trigger spots of rabbit skeletal muscle. *Am J Phys Med Rehabil* 2001;80(10):729-35. doi: 10.1097/00002060-200110000-00004 [published Online First: 2001/09/20]
8. Hsieh YL, Chou LW, Joe YS, et al. Spinal cord mechanism involving the remote effects of dry needling on the irritability of myofascial trigger spots in rabbit skeletal muscle. *Arch Phys Med Rehabil* 2011;92(7):1098-105. doi: 10.1016/j.apmr.2010.11.018 [published Online First: 2011/05/03]
9. Cagnie B, Dewitte V, Barbe T, et al. Physiologic effects of dry needling. *Curr Pain Headache Rep* 2013;17(8):348. doi: 10.1007/s11916-013-0348-5 [published Online First: 2013/06/27]

10. Cagnie B, Castelein B, Pollie F, et al. Evidence for the Use of Ischemic Compression and Dry Needling in the Management of Trigger Points of the Upper Trapezius in Patients with Neck Pain: A Systematic Review. *Am J Phys Med Rehabil* 2015;94(7):573-83. doi: 10.1097/phm.0000000000000266 [published Online First: 2015/03/15]

11. Trinh K, Graham N, Irnich D, et al. Acupuncture for neck disorders. *Cochrane Database Syst Rev* 2016(5):Cd004870. doi: 10.1002/14651858.CD004870.pub4 [published Online First: 2016/05/05]

12. Liu L, Huang QM, Liu QG, et al. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. *Arch Phys Med Rehabil* 2015;96(5):944-55. doi: 10.1016/j.apmr.2014.12.015 [published Online First: 2015/01/13]

13. Kumbhare D, Singh D, Rathbone HA, et al. Ultrasound-Guided Interventional Procedures: Myofascial Trigger Points With Structured Literature Review. *Reg Anesth Pain Med* 2017;42(3):407-12. doi: 10.1097/aap.0000000000000572 [published Online First: 2017/03/10]

14. Gattie E, Cleland JA, Snodgrass S. The Effectiveness of Trigger Point Dry Needling for Musculoskeletal Conditions by Physical Therapists: A Systematic Review and Meta-analysis. *J Orthop Sports Phys Ther* 2017;47(3):133-49. doi: 10.2519/jospt.2017.7096 [published Online First: 2017/02/06]

15. Hall ML, Mackie AC, Ribeiro DC. Effects of dry needling trigger point therapy in the shoulder region on patients with upper extremity pain and dysfunction: a systematic review with meta-analysis. *Physiotherapy* 2018;104(2):167-77. doi: 10.1016/j.physio.2017.08.001 [published Online First: 2018/02/15]

16. Sam J, Catapano M, Sahni S, et al. Pulsed Radiofrequency in Interventional Pain Management: Cellular and Molecular Mechanisms of Action - An Update and Review. *Pain Physician* 2021;24(8):525-32. [published Online First: 2021/11/19]

17. Jorge DMF, Huber SC, Rodrigues BL, et al. The Mechanism of Action between Pulsed Radiofrequency and Orthobiologics: Is There a Synergistic Effect? *Int J Mol Sci* 2022;23(19) doi: 10.3390/ijms231911726 [published Online First: 2022/10/15]

18. Niraj G. Ultrasound-guided pulsed radiofrequency treatment of myofascial pain syndrome: a case series. *Br J Anaesth* 2012;109(4):645-6. doi: 10.1093/bja/aes331 [published Online First: 2012/09/15]

19. Tamimi MA, McCeney MH, Krutsch J. A case series of pulsed radiofrequency treatment of myofascial trigger points and scar neuromas. *Pain Med* 2009;10(6):1140-3. doi: 10.1111/j.1526-4637.2009.00646.x [published Online First: 2009/07/15]

20. Park CH, Lee YW, Kim YC, et al. Treatment experience of pulsed radiofrequency under ultrasound guided to the trapezius muscle at myofascial pain syndrome -a case report. *Korean J Pain* 2012;25(1):52-4. doi: 10.3344/kjp.2012.25.1.52 [published Online First: 2012/01/20]

21. Cho IT, Cho YW, Kwak SG, et al. Comparison between ultrasound-guided interfascial pulsed radiofrequency and ultrasound-guided interfascial block with local anesthetic in myofascial pain syndrome of trapezius muscle. *Medicine (Baltimore)* 2017;96(5):e6019. doi: 10.1097/md.0000000000006019 [published Online First: 2017/02/06]

22. Park SM, Cho YW, Ahn SH, et al. Comparison of the Effects of Ultrasound-Guided Interfascial Pulsed Radiofrequency and Ultrasound-Guided Interfascial Injection on Myofascial Pain Syndrome of the Gastrocnemius. *Ann Rehabil Med* 2016;40(5):885-92. doi: 10.5535/arm.2016.40.5.885 [published Online First: 2016/11/17]

23. Liu L, Huang QM, Liu QG, et al. Evidence for Dry Needling in the Management of Myofascial Trigger Points Associated With Low Back Pain: A Systematic Review and Meta-Analysis. *Arch Phys Med Rehabil* 2018;99(1):144-52.e2. doi: 10.1016/j.apmr.2017.06.008 [published Online First: 2017/07/12]

24. Simons DG TJ, Simons LS. Myofascial paini and dysfunction. The trigger point manual. Upper Half of Body Baltimore: Williams & Wilkins 1999.

25. Farrar JT, Portenoy RK, Berlin JA, et al. Defining the clinically important difference in pain outcome measures. *Pain* 2000;88(3):287-94. doi: 10.1016/s0304-3959(00)00339-0 [published Online First: 2000/11/09]

26. Hong C-Z. Considerations and Recommendations Regarding Myofascial Trigger Point Injection. *Journal of Musculoskeletal Pain* 1994;2(1):29-59. doi: 10.1300/J094v02n01_03

27. Espejo-Antúnez L, Tejeda JF, Albornoz-Cabello M, et al. Dry needling in the management of myofascial trigger points: A systematic review of randomized controlled trials. *Complement Ther Med* 2017;33:46-57. doi: 10.1016/j.ctim.2017.06.003 [published Online First: 2017/07/25]

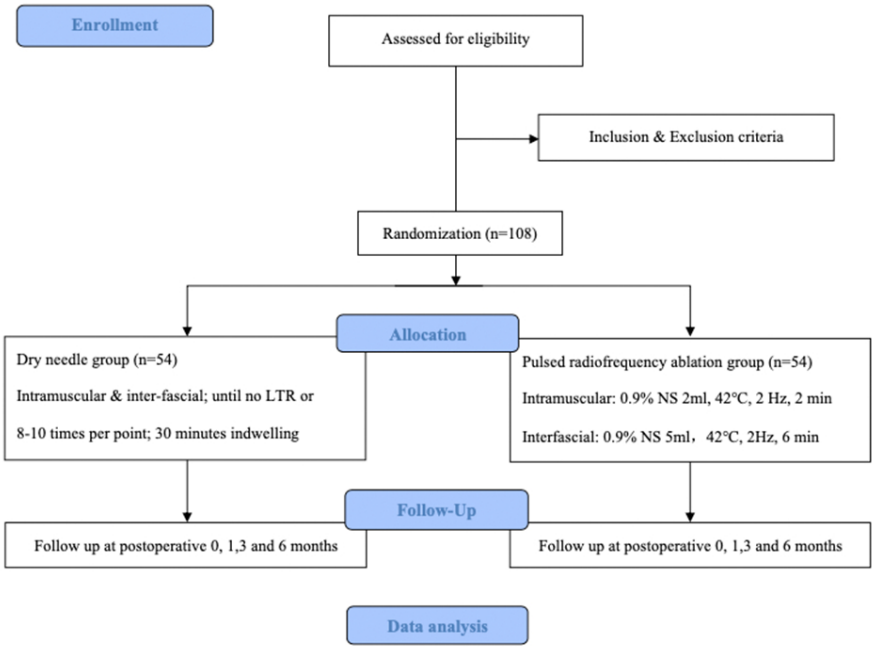
28. Butts R, Dunning J, Serafino C. Dry needling strategies for musculoskeletal conditions: Do the number of needles and needle retention time matter? A narrative literature review. *J Bodyw Mov Ther* 2021;26:353-63. doi: 10.1016/j.jbmt.2020.12.003 [published Online First: 2021/05/17]

29. Lim HHR, Tang ZY, Hashim M, et al. Cross-cultural Adaptation, Reliability, Validity, and Responsiveness of the Simplified-Chinese Version of Neck Disability Index. *Spine (Phila Pa 1976)* 2020;45(8):541-48. doi: 10.1097/brs.0000000000003325 [published Online First: 2019/11/27]

30. Wang W, Bian Q, Zhao Y, et al. Reliability and validity of the Chinese version of the Patient Health Questionnaire (PHQ-9) in the general population. *Gen Hosp Psychiatry* 2014;36(5):539-44. doi: 10.1016/j.genhosppsych.2014.05.021 [published Online First: 2014/07/16]

31. Yu J, Coons SJ, Draugalis JR, et al. Equivalence of Chinese and US-English versions of the SF-36 health survey. *Qual Life Res* 2003;12(4):449-57. doi: 10.1023/a:1023446110727 [published Online First: 2003/06/12]

Figure 1. Flowchart of the study protocol.



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SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description	
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	Pg.1, line 1-2
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	Pg.2, line 20
	2b	All items from the World Health Organization Trial Registration Data Set	N/A (clinicaltrials.gov)
Protocol version	3	Date and version identifier	Pg.2, line 21
Funding	4	Sources and types of financial, material, and other support	Pg 15, line 9-11
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	Pg.1, line 3-7, Pg. 15, line 1-3
	5b	Name and contact information for the trial sponsor	Pg.15, line 12-13
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	Pg.15, line 12-13

	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	N/A
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	Pg 4, line 8-27; Pg 5, line 1-14;
	6b	Explanation for choice of comparators	Pg.4, line 10-11; Pg.5, line 10-14;
Objectives	7	Specific objectives or hypotheses	Pg.5, line 17-20
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	Pg.6, line 3. Pg.11, line 6.
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	Pg 6, line 3-4.
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	Pg.6, line 9 to Pg.7, line 1;
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	Pg.7, line 3 to Pg.9, line 4
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	Pg.14, line 6-8.

	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	Pg.12, line 3-5
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	Pg.6, line 18-19
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	Pg.9, line 6 -14
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	Pg.9, line 17-20, Table 1
Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	Pg.10, line 4-8
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	Pg.10, line 10 to Pg. 11, line 3
Methods: Assignment of interventions (for controlled trials)			
Allocation:			
Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	Pg.11, line 6-7
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	Pg.11, line 7-11

Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	Pg.11, line 6-11
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	Pg.11, line 14-24
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	Pg.11, line 22
Methods: Data collection, management, and analysis			
Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	Pg.12 line 2-6, Pg. 9, line 10-14
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	Pg. 12, line 5-6
Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	Pg.12, line 9-11
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	Pg.12, line 14 to Pg.13, line 2
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	N/A
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	Pg.12, line 14,24-27
Methods: Monitoring			

Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	Pg.13, line 5-7
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	Pg.13, line 7-9
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	Pg.13, line 11-14
Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	Pg.13, line 7
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	Pg. 14, line 2
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	Pg.14, line 5-6
Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	Pg.14, line 3-6
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	N/A
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	Pg. 14, line 10-12

Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	Pg.16, line 6
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	Pg.14, line 13-15
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	Pg.14, line 15-17
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	Pg.14, line 17-18
	31b	Authorship eligibility guidelines and any intended use of professional writers	Pg.14, line 19-20
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	N/A
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	Supplement file 2
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	N/A

*It is strongly recommended that this checklist be read in conjunction with the SPIRIT 2013 Explanation & Elaboration for important clarification on the items. Amendments to the protocol should be tracked and dated. The SPIRIT checklist is copyrighted by the SPIRIT Group under the Creative Commons "Attribution-NonCommercial-NoDerivs 3.0 Unported" license.

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Ultrasound-guided pulsed radiofrequency versus dry needling for pain management in chronic neck and shoulder myofascial pain patients at a tertiary hospital in China: A randomized controlled trial protocol

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Ultrasound-guided pulsed radiofrequency versus dry needling for pain management in chronic neck and shoulder myofascial pain patients at a tertiary hospital in China: A randomized controlled trial protocol

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Abstract

Introduction: Myofascial pain, especially in the neck and shoulder region, is one of the most common chronic pain disorders worldwide. Dry needling (DN) and pulsed radiofrequency (PRF) are two effective methods for treating myofascial pain. We aimed to compare the effects of DN and PRF in chronic neck and shoulder myofascial pain patients.

Methods and analysis: This is a prospective, single-center, randomized, controlled trial in a tertiary hospital. We plan to recruit 108 patients aged 18 to 70 years old who are diagnosed with chronic myofascial pain in the neck, shoulder, and upper back regions and randomly allocate them to either the DN or PRF group at a 1:1 ratio. The DN group will receive ultrasound-guided intramuscular and interfascial dry needling 8-10 times per pain point or until local twitch responses are no longer elicited, and 30 minutes of indwelling. The PRF group will receive ultrasound-guided intramuscular (0.9% saline 2 ml, 42℃, 2 Hz, 2 minutes) and interfascial (0.9% saline 5 ml, 42℃, 2 Hz, 2 minutes) pulsed radiofrequency. Follow-up will be performed by the research assistant at 0, 1, 3, and 6 months postoperatively. The primary outcome is the postoperative six-month pain visual analog score (0-100 mm). Secondary outcomes include pressure pain threshold measured by an algometer, neck disability index (NDI), depression (PHQ-9), anxiety (GAD-7), sleep status (Likert scale), and overall quality of life (SF-36). Between-group comparisons will be analyzed using either a nonparametric test or a mixed-effects linear model.

Ethics and dissemination: This study was approved by the Medical Ethics Committee of Peking Union Medical College Hospital (JS-3399). All participants will give written informed consent before participation. The results from this study will be shared at conferences and disseminated in international journals.

Strengths and limitations of this study

- This is a prospective, randomized, and controlled clinical trial.
- This study will compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in myofascial pain patients. To the best of our knowledge, we have not identified any similar study.
- This study has a 6-month follow-up period. In addition to pain, patients' neck function, depression, anxiety, sleep, and overall quality of life will also be evaluated and reported.
- Findings from the study may provide more evidence to guide clinical practice in myofascial pain patients.
- The study results may not be applicable to radiofrequency ablation or dry needling treatment using other parameters.

Introduction

Background and rationale

Myofascial pain (MPS) is the leading cause of chronic and persistent regional pain, affecting as many as 85% of the general population [1 2]. The neck and shoulder are some of the most commonly involved pain regions and are the leading causes of disability worldwide[3 4]. The exact mechanism of myofascial pain has not been fully illustrated. However, existing studies have suggested that muscle overuse or trauma, ergonomic and structural factors, and psychological stress might be potential causes or triggers of this disorder [1].

A variety of treatment methods for myofascial pain have been investigated, including injection of saline, local anesthetics and/or steroids, dry needling, mini-scalpel, rich platelet plasma injection, and pulsed radiofrequency. Among these methods, ultrasound-guided dry needling (DN) and pulsed radiofrequency (PRF) of the pain region have been considered two effective and promising treatments for myofascial pain [5 6].

Dry needling is the insertion of a thin needle into a muscle pain region to alleviate pain. The exact analgesic mechanisms have not been unraveled, but it is hypothesized that DN may increase endplate discharge and local blood flow, reduce spontaneous electrical activities and acetylcholine stores, and change the release of descending inhibitory neurotransmitters as well as the central and peripheral sensitization process [7-9]. Tellez et al.'s study on 130 nonspecific neck pain patients showed that dry needling can effectively reduce pain intensity, mechanical hyperalgesia, neck active angle of motion and muscle strength at 1, 3 and 6 months postoperatively [6]. Several meta-analysis results also supported the use of dry needling, especially deep dry needling, in the management of chronic myofascial pain [10-12]. Cagnie et al. reviewed fifteen randomized controlled trials including approximately 800 patients and concluded that there was strong evidence for dry needling to have a positive effect on pain intensity[10]. In addition, the use of ultrasonography further improves procedural safety and accuracy [5 13]. However, dry needling is not an all-around treatment method. There were still some patients who did not respond well to it [14 15] and were in request of new therapies.

Pulsed radiofrequency is an important and effective interventional treatment for chronic neuropathic pain disorders. It generates an electromagnetic field in the pain region that acts on several biological pathways, including ion channels, neurotransmitters, postsynaptic receptors, and immune activities [16], thus eliciting a neuromodulation effect [17]. Recent studies have reported that ultrasound-guided PRF might also be a promising

treatment for chronic myofascial pain [18-21]. Niraj administered PRF and steroid injections to twelve patients with abdominal rectus muscle pain. At the six-month postoperative follow-up, eight patients had 50% pain relief [18]. Cho et al. compared the analgesic effects of interfascial PRF (42 °C, 5 Hz, 55 V) and local anesthetic (0.6% lidocaine 10 ml) injection in trapezius and rhomboid muscle pain patients, and the results showed that the pain visual analog score (VAS) of the PRF group was lower than that of the local anesthetic injection group at 4 and 8 weeks postoperatively [21]. Park et al. compared the analgesic effects of interfascial PRF and local anesthetic injection on gastrocnemius and soleus muscle pain patients, and the results showed that the pain intensity and physical and mental component summary scores were better in the PRF group than in the injection group [22]. However, both studies performed treatment only once and followed the patients for only two months. Myofascial pain always requires multiple sessions of continuous treatment and long-term management [23]. To date, there are currently a lack of high-quality studies on the treatment effects of PRF in myofascial pain patients, and it is also unknown whether PRF can exhibit a superior analgesic effect to DN. Since placebo/sham comparison of each individual intervention provides only limited information, we decided to design a parallel study comparing the two interventions together.

Objectives

This study aims to compare the treatment effects of ultrasound-guided pulsed radiofrequency and dry needling in chronic myofascial pain patients. We hypothesized that at the six-month postoperative follow-up, the pain VAS of patients undergoing PRF would be lower than that of patients undergoing DN, and the differences in pain VAS between the PRF and DN groups would be statistically significant.

Methods and analysis

Trial design and study setting

This is a parallel, randomized, equivalence trial that will be conducted at the Peking Union Medical College Hospital in Beijing, China. The proposed trial was designed by following the SPIRIT guidelines (supplement file 1) and approved by the institutional review board (JS-3399). We will report it in accordance with the guidelines of the Consolidated Standards of Reporting Trials (CONSORT). The planned start and end dates of the study are September 1, 2023, and June 1, 2025, respectively.

Eligible criteria

Participants must meet all the following criteria for inclusion:

1. Aged between 18 and 70 years old.
2. Chronic (>3 months) myofascial pain in the neck, shoulder, and upper back region.
3. Myofascial pain will be diagnosed based on Simons and Travell's criteria: taut band palpable, exquisite spot tenderness of a nodule in a taut band, patient's recognition of current pain complaint by pressure on the tender nodule, and painful limit to full stretch range of motion[6 24].
4. Have at least a pain VAS score of 40 mm; thus, a minimal clinically significant change is detectable [25].

Participants must meet at least one of the following criteria for exclusion:

1. History of receiving DN or PRF treatment or currently undergoing other pain-related treatments (acupuncture, laser, infrared therapy, etc.).
2. Presence or history of trauma, surgery, or infection in the pain region.
3. Current or history of taking moderate to strong analgesics, such as tramadol and morphine.
4. Severe systemic disease (eg. severe hepatic or renal dysfunction), coagulopathy, or medications affecting the coagulation system.
5. Allergy to medications used.
6. Pregnancy, psychiatric disease, medical background, inability to cooperate, or refusal to participate.

Participants who meet the following criteria will be withdrawn from the study.

1. Unwilling to continue participation or unable to follow the treatment plan.

2. Unable to obtain the primary outcome data due to any reason.

Interventions

The workflow of this trial is described in Figure 1. Patients from the pain clinics of the study hospital will be screened for eligibility. After obtaining informed consent, all participants will complete the baseline assessment form and be randomized to either the DN or PRF group before treatment.

Pretreatment assessment

Baseline assessments, including participants' demographics, clinical data, and questionnaire answers, will be collected using a digital health care system. Demographic data included age, sex, body mass index (BMI), occupation, and educational level. Clinical data included sites, duration, and characteristics of pain, pain degree measured by VAS, neck disability index, depression measured by the patient health questionnaire (PHQ-9) scale, anxiety measured by the generalized anxiety disorder (GAD-7) scale, sleep status measured by the Likert scale and overall quality of life measured by the health-related quality of life questionnaire (SF-36).

Prepare

The whole procedure will be performed in a standard operating room with qualified disinfection and surgical kits, an ultrasound machine (Sonosite X-port, USA) and a pulsed radiofrequency machine (R-2000B A1 Beiqi Corp, China). A certified pain clinician with three years of fellowship training and five years of independent clinical practice experience will provide treatment for all participants with assistance from a pain nurse with more than ten years of nursing experience.

After putting the patient in the prone position on the operating table with vital signs monitored, the pain clinician will palpate the patient and mark the pain regions with "×------×". The pressure pain threshold will be measured at the center of the marked pain region using an algometer with a probe area of 1 cm^2. The algometer will be applied perpendicular to the tissue at a constant rate of approximately 30 kPa/s. A 30-second resting period will be allowed between each measure to avoid temporal summation, and the average of three trials will

be calculated and recorded as the final results. Then, patients will be sterilized and draped using a standard fashion; thus, the whole procedure can only be felt but not seen by the patient.

Both interventions will be performed under real-time ultrasound guidance (Sonosite X-port, USA) with the transducer covered by sterilized protective bags. A linear transducer will be placed on the marked pain region to identify the musculoskeletal structures, including the superficial and deep muscle layers, as well as the fascia. The ultrasound parameters will be set as follows: linear transducer 4-13 Hz, MSK general mode, target depth 3-5 cm, medium brightness.

Pulsed radiofrequency

After using ultrasound to identify the muscle and fascia of the pain region, a radiofrequency cannula (20G, Inomed Corp, German) will be inserted into the previously marked pain region under real-time ultrasound guidance. PRF will be performed both in the superficial (trapezius muscle, supraspinatus muscle) and deep (splenius capitis, rhomboid muscle, levator scapulae) muscle layers, as well as in the fascia between the two layers. Intramuscular PRF will be performed after injecting 2 ml of 0.9% saline into the muscle using the following parameters: 42 °C, 2 Hz, 2 minutes. Interfascial PRF will be performed after injecting 5 ml of 0.9% saline into the fascia layers using the following parameters: 42 °C, 2 Hz, 6 minutes. After PRF, the cannula will be extracted, and the wound will be covered with sterilized cotton.

Dry needling

After using ultrasound to identify the muscle and fascia of the pain region, a thin acupuncture needle (0.03 mm, 60-100 mm, Chengzhen Corp, China) will be inserted into the previously marked pain region under real-time ultrasound guidance. Then, rapid insertion of the needle in and out of the pain point will be performed in a way similar to Hong's fast-in and fast-out technique[26]. Based on previous study experiences, dry needling will be performed either until local twitch responses are no longer elicited or 8 to 10 times per pain point and indwelled for 30 minutes [23 27 28]. Then, the needle will be extracted, and hemostatic compression will be applied on the needled muscle.

Follow-up

Both PRF and DN will be repeated every week for a total of four times. Follow-up will be completed during an outpatient visit by an experienced clinician blinded to group allocation at 0, 1, 3, and 6 months after cessation of the treatment program.

Outcomes

The primary outcome is patients' pain VAS at the six-month postoperative follow-up. The pain VAS measures pain intensity on a line of 100 mm, with 0 mm indicating no pain and 100 mm indicating the worst imaginable pain [25].

Secondary outcomes include pressure pain threshold measured by an algometer, depression measured by the patient health questionnaire (PHQ-9), anxiety measured by the generalized anxiety disorder (GAD-7) scale, neck disability index (NDI) scale, sleep quality measured by the Likert scale and overall quality of life measured by the health-related quality of life (SF-36) scale. All scales provided to participants will be corresponding validated Chinese versions [29-31].

Participant timeline

The participant timeline is listed in Table 1. The recruitment and baseline assessment will last one week. The intervention period will last 4 weeks, starting after the baseline assessment. The follow-up period will last six months, starting at the end of the intervention period. Patients will be asked to measure the pressure pain threshold and complete questionnaires during follow-up visits at 0, 1, 3, and 6 months after the intervention period.

Table 1. Schedule of enrollment, interventions, and assessments.

	Enrollment	Baseline	Intervention				Follow up			
Timeline	$-t_1$	0	t_{11}	t_{12}	t_{13}	t_{14}	t_{21}	t_{22}	t_{23}	t_{24}
Enrollment	×									
Eligibility screen	×									

Informed consent	×									
Baseline assessment		×								
Randomization		×								
Allocation		×								
Interventions										
DN			×	×	×	×				
PRF			×	×	×	×				
Assessments										
Pain VAS		×					×	×	×	×
Pain threshold		×					×	×	×	×
NDI		×					×	×	×	×
PHQ-9		×					×	×	×	×
GAD-7		×					×	×	×	×
Sleep Likert scale		×					×	×	×	×
SF-36		×					×	×	×	×

t_1=pre-intervention; 0=baseline assessment; t_{11}-t_{14}: intervention; t_{21}-t_{24}: follow-up

Sample size

The sample size was calculated based on a null hypothesis of the primary outcome, pain VAS at six months postoperatively. According to prior study and our pilot study experiences, the pain VAS after DN and PRF treatment was (38±15) mm and (26±18) mm, respectively [5]. Assuming an α of 0.05 and β of 0.9, forty-two patients will be needed in each group to detect significant differences. Accounting for a 20% dropout rate, a total of 108 patients will be recruited.

Recruitment

All patients visiting the pain clinics of the study hospital can be invited by clinicians to participate in this trial. These patients will be informed of the trial by the clinicians. If a patient intends to participate, the

research team will be contacted to provide further information on the trial. If a patient confirms participation, eligibility will be checked, and informed consent will be signed. After completion of the baseline assessment, randomization will be performed by a research member, and the clinician responsible for the patient's treatment will be informed of the randomization result.

Allocation

Participants will be randomly allocated to either PRF or DN groups at a 1:1 ratio by a research member based on a computer-generated randomization result. According to a pregenerated random sequence, each enrolled patient will be given a sealed opaque envelope based on the order of enrollment. After the patient has been sterilized, a pain nurse will open the sealed envelope and assign the patient to the corresponding group according to the random number in the envelope, and an experienced clinician will perform the corresponding treatment on the patient.

Blinding

The clinician responsible for participants' treatment will not be blinded to group allocation. The researchers responsible for postoperative follow-up and statistical analysis will be blinded to group allocation. The pain clinician will try his or her best to blind the patients as much as possible during treatment. For instance, a patient will be asked to lie in the prone position and covered with sterilized drapes so that the whole treatment procedure can only be felt but not seen by the patient. A research assistant will broadcast the sound of PRF during DN treatment to simulate similar scenarios. The adequacy of blinding will be tested after completion of the treatment by asking the participants to guess whether they received DN or PRF. The questionnaire will have seven choices: certainly DN, certainly PRF, probably DN, probably PRF, possibly DN, possibly PRF, and do not know. Unblinding will be carried out after completion of the statistical analysis. Participants who select "certainly", "probably", "possibly" and are correct about the answer are considered correct.

Data collection

After signing informed consent, a dedicated research member will guide the participants in completing the baseline assessment. Subsequently, the participants will be randomized to one of the two intervention groups. Participants will be asked to complete follow-up assessments during outpatient clinic revisits at 0, 1, 3, and 6 months after completion of the entire treatment program. If a participant does not show up during the revisit, a telephone call will be made to remind the participant. All questionnaires can also be sent as online links to participants via short messages.

Data management

Data will be managed using a digital health care system. A unique code will be allocated to each participant and recorded on trial documents, except for informed consent and contact details. The identifiable data of each participant will be stored separately and securely from other study data.

Statistical methods

Statistical analysis will follow the intention-to-treat principle. Based on previous studies and our clinical experiences, the postoperative six-month pain VAS will have a highly skewed distribution; hence, the primary outcome, the postoperative six-month pain VAS, will be analyzed using the Mann–Whitney U test. Median difference with 95% confidence interval will be reported as effect size using Hodges–Lehmann's method. Secondary outcomes, including pain, psychological, sleep and life quality scale scores at different postoperative time points, will be analyzed using the mixed-effects linear model, in which the outcome measure will be regressed against the fixed-effect group allocation, categorial time points, and interaction between group allocation and time. A random-effects intercept will be included in the model without any random-effects slope, and autoaggressive 1 will be used as the covariance structure. The marginal group difference with a 95% confidence interval estimated by the mixed-effects model will be used as the effect size for secondary outcomes.

If missing data occurred in the primary outcome, the last observation carried forward method was used for data imputation. A complete case dataset without any imputation will be used in the secondary outcomes. No adjustment for multiplicity will be conducted among different secondary outcomes; hence, relevant findings

will be interpreted only as exploratory results. Data analysis will be conducted in Statistical Package for the Social Sciences (SPSS, Chicago, Illinois, USA) version 23.0. A two-sided *P* value less than 0.05 was regarded as statistically significant.

Data monitoring and auditing

Data monitoring will be performed once per year by independent monitors. No Data Monitoring Committee will be assigned to this study since the risks of interventions are relatively low and the study period is short. Trial conduct and data integrity will also be audited once a year by independent auditors. We plan to perform an interim analysis after half of the patients are included. The sponsors and researchers will have access to these interim results and make the final decision of whether to continue or terminate the trial.

Harms

Adverse events will be reported by participant self-report questionnaires. The pain clinicians responsible for patient treatment will be asked to report serious adverse events to the research team. The research team will report these adverse events to the Ethics Committee.

Patient and public involvement

Before study design, myofascial pain patients who recently visited the hospital pain clinics were contacted to participate in the research patient panel and provide opinions on the research question, outcome measures, burden of intervention, as well as their experiences and preferences. These patients can comment on the study design and help disseminate the final results, but they will not be involved in the recruitment or conduct of the study.

Ethics and dissemination

This study was approved by the ethics committee of Peking Union Medical College Hospital (JS-3399), was registered at Clinicaltrials.gov (NCT 05637047) and will adhere to the Declaration of Helsinki. Protocol modifications will require a formal amendment to the protocol with agreement from the project management committee (WJ, ZYL, CXL) and updates in the trial registry (Clinicaltrials.gov). Then, a research member will inform the participants. Participants have the right to withdraw from the study at any time. The researchers can also discontinue treatment for a participant's best interest (eg. severe adverse events). All changes in the participant's intervention will be recorded in detail in the case report form. All participants will be given detailed information about the trial by a research member, and reflection time will be given before signing informed consent (supplement file 2), which will be requested before participation. Participant confidentiality will be ensured according to laws and regulations. Participants' data will be maintained in secure storage at the coordinating center for 5 years after completion of the study.

The primary data can be accessed by a dedicated research member during data collection. After the final dataset is formed from the primary data, dataset access will be limited to statisticians and all authors of the final publication. Patients will be treated during the trial with the best intention. There will be no ancillary or posttrial care. Participants will not receive any compensation from the harm of the treatment beyond the compensation from the National Medicare System if malpractice has taken place. Study results will be disseminated at medical conferences, and we also intend to publish our findings in an international journal. Substantial contributions to the conception or design of the study; acquisition, analysis or interpretation of data; draft or revision of the manuscript will be warranted as author. No professional writers will be invited.

Figure legends

Figure 1. Flowchart of the study protocol.

LTR: local twitch response

Contributorship statement

WJ and CXL designed the study, ZYL revised the statistical design, WJ and ZYL drafted the manuscript, and CXL and SL revised the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Full References

1. Galasso A, Urits I, An D, et al. A Comprehensive Review of the Treatment and Management of Myofascial Pain Syndrome. *Curr Pain Headache Rep* 2020;24(8):43. doi: 10.1007/s11916-020-00877-5 [published Online First: 2020/07/01]
2. Li X, Wang R, Xing X, et al. Acupuncture for Myofascial Pain Syndrome: A Network Meta-Analysis of 33 Randomized Controlled Trials. *Pain Physician* 2017;20(6):E883-e902. [published Online First: 2017/09/22]
3. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1545-602. doi: 10.1016/s0140-6736(16)31678-6 [published Online First: 2016/10/14]
4. Heredia-Rizo AM, Petersen KK, Madeleine P, et al. Clinical Outcomes and Central Pain Mechanisms are Improved After Upper Trapezius Eccentric Training in Female Computer Users With Chronic Neck/Shoulder Pain. *Clin J Pain* 2019;35(1):65-76. doi: 10.1097/ajp.0000000000000656 [published Online First: 2018/09/18]
5. Diep D, Chen KJQ, Kumbhare D. Ultrasound-guided interventional procedures for myofascial trigger points: a systematic review. *Reg Anesth Pain Med* 2021;46(1):73-80. doi: 10.1136/rapm-2020-101898 [published Online First: 2020/11/08]
6. Cerezo-Téllez E, Torres-Lacomba M, Fuentes-Gallardo I, et al. Effectiveness of dry needling for chronic nonspecific neck pain: a randomized, single-blinded, clinical trial. *Pain* 2016;157(9):1905-17. doi: 10.1097/j.pain.0000000000000591 [published Online First: 2016/08/19]
7. Chen JT, Chung KC, Hou CR, et al. Inhibitory effect of dry needling on the spontaneous electrical activity recorded from myofascial trigger spots of rabbit skeletal muscle. *Am J Phys Med Rehabil* 2001;80(10):729-35. doi: 10.1097/00002060-200110000-00004 [published Online First: 2001/09/20]
8. Hsieh YL, Chou LW, Joe YS, et al. Spinal cord mechanism involving the remote effects of dry needling on the irritability of myofascial trigger spots in rabbit skeletal muscle. *Arch Phys Med Rehabil* 2011;92(7):1098-105. doi: 10.1016/j.apmr.2010.11.018 [published Online First: 2011/05/03]
9. Cagnie B, Dewitte V, Barbe T, et al. Physiologic effects of dry needling. *Curr Pain Headache Rep* 2013;17(8):348. doi: 10.1007/s11916-013-0348-5 [published Online First: 2013/06/27]

10. Cagnie B, Castelein B, Pollie F, et al. Evidence for the Use of Ischemic Compression and Dry Needling in the Management of Trigger Points of the Upper Trapezius in Patients with Neck Pain: A Systematic Review. *Am J Phys Med Rehabil* 2015;94(7):573-83. doi: 10.1097/phm.0000000000000266 [published Online First: 2015/03/15]

11. Trinh K, Graham N, Irnich D, et al. Acupuncture for neck disorders. *Cochrane Database Syst Rev* 2016(5):Cd004870. doi: 10.1002/14651858.CD004870.pub4 [published Online First: 2016/05/05]

12. Liu L, Huang QM, Liu QG, et al. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. *Arch Phys Med Rehabil* 2015;96(5):944-55. doi: 10.1016/j.apmr.2014.12.015 [published Online First: 2015/01/13]

13. Kumbhare D, Singh D, Rathbone HA, et al. Ultrasound-Guided Interventional Procedures: Myofascial Trigger Points With Structured Literature Review. *Reg Anesth Pain Med* 2017;42(3):407-12. doi: 10.1097/aap.0000000000000572 [published Online First: 2017/03/10]

14. Gattie E, Cleland JA, Snodgrass S. The Effectiveness of Trigger Point Dry Needling for Musculoskeletal Conditions by Physical Therapists: A Systematic Review and Meta-analysis. *J Orthop Sports Phys Ther* 2017;47(3):133-49. doi: 10.2519/jospt.2017.7096 [published Online First: 2017/02/06]

15. Hall ML, Mackie AC, Ribeiro DC. Effects of dry needling trigger point therapy in the shoulder region on patients with upper extremity pain and dysfunction: a systematic review with meta-analysis. *Physiotherapy* 2018;104(2):167-77. doi: 10.1016/j.physio.2017.08.001 [published Online First: 2018/02/15]

16. Sam J, Catapano M, Sahni S, et al. Pulsed Radiofrequency in Interventional Pain Management: Cellular and Molecular Mechanisms of Action - An Update and Review. *Pain Physician* 2021;24(8):525-32. [published Online First: 2021/11/19]

17. Jorge DMF, Huber SC, Rodrigues BL, et al. The Mechanism of Action between Pulsed Radiofrequency and Orthobiologics: Is There a Synergistic Effect? *Int J Mol Sci* 2022;23(19) doi: 10.3390/ijms231911726 [published Online First: 2022/10/15]

18. Niraj G. Ultrasound-guided pulsed radiofrequency treatment of myofascial pain syndrome: a case series. *Br J Anaesth* 2012;109(4):645-6. doi: 10.1093/bja/aes331 [published Online First: 2012/09/15]

19. Tamimi MA, McCeney MH, Krutsch J. A case series of pulsed radiofrequency treatment of myofascial trigger points and scar neuromas. *Pain Med* 2009;10(6):1140-3. doi: 10.1111/j.1526-4637.2009.00646.x [published Online First: 2009/07/15]

20. Park CH, Lee YW, Kim YC, et al. Treatment experience of pulsed radiofrequency under ultrasound guided to the trapezius muscle at myofascial pain syndrome -a case report. *Korean J Pain* 2012;25(1):52-4. doi: 10.3344/kjp.2012.25.1.52 [published Online First: 2012/01/20]

21. Cho IT, Cho YW, Kwak SG, et al. Comparison between ultrasound-guided interfascial pulsed radiofrequency and ultrasound-guided interfascial block with local anesthetic in myofascial pain syndrome of trapezius muscle. *Medicine (Baltimore)* 2017;96(5):e6019. doi: 10.1097/md.0000000000006019 [published Online First: 2017/02/06]

22. Park SM, Cho YW, Ahn SH, et al. Comparison of the Effects of Ultrasound-Guided Interfascial Pulsed Radiofrequency and Ultrasound-Guided Interfascial Injection on Myofascial Pain Syndrome of the Gastrocnemius. *Ann Rehabil Med* 2016;40(5):885-92. doi: 10.5535/arm.2016.40.5.885 [published Online First: 2016/11/17]

23. Liu L, Huang QM, Liu QG, et al. Evidence for Dry Needling in the Management of Myofascial Trigger Points Associated With Low Back Pain: A Systematic Review and Meta-Analysis. *Arch Phys Med Rehabil* 2018;99(1):144-52.e2. doi: 10.1016/j.apmr.2017.06.008 [published Online First: 2017/07/12]

24. Simons DG TJ, Simons LS. Myofascial paini and dysfunction. The trigger point manual. Upper Half of Body Baltimore: Williams & Wilkins 1999.

25. Farrar JT, Portenoy RK, Berlin JA, et al. Defining the clinically important difference in pain outcome measures. *Pain* 2000;88(3):287-94. doi: 10.1016/s0304-3959(00)00339-0 [published Online First: 2000/11/09]

26. Hong C-Z. Considerations and Recommendations Regarding Myofascial Trigger Point Injection. *Journal of Musculoskeletal Pain* 1994;2(1):29-59. doi: 10.1300/J094v02n01_03

27. Espejo-Antúnez L, Tejeda JF, Albornoz-Cabello M, et al. Dry needling in the management of myofascial trigger points: A systematic review of randomized controlled trials. *Complement Ther Med* 2017;33:46-57. doi: 10.1016/j.ctim.2017.06.003 [published Online First: 2017/07/25]

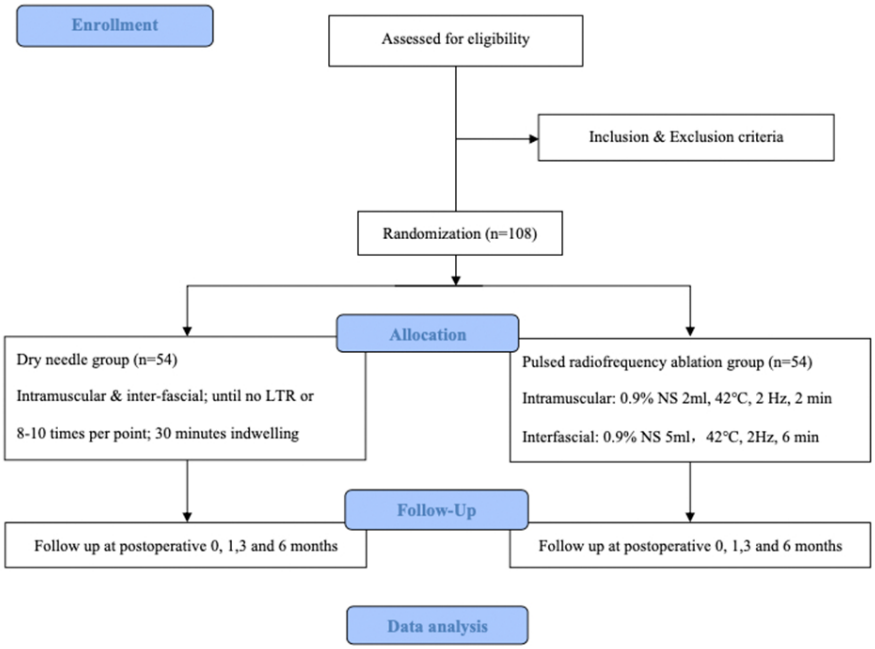
28. Butts R, Dunning J, Serafino C. Dry needling strategies for musculoskeletal conditions: Do the number of needles and needle retention time matter? A narrative literature review. *J Bodyw Mov Ther* 2021;26:353-63. doi: 10.1016/j.jbmt.2020.12.003 [published Online First: 2021/05/17]

29. Lim HHR, Tang ZY, Hashim M, et al. Cross-cultural Adaptation, Reliability, Validity, and Responsiveness of the Simplified-Chinese Version of Neck Disability Index. *Spine (Phila Pa 1976)* 2020;45(8):541-48. doi: 10.1097/brs.0000000000003325 [published Online First: 2019/11/27]

30. Wang W, Bian Q, Zhao Y, et al. Reliability and validity of the Chinese version of the Patient Health Questionnaire (PHQ-9) in the general population. *Gen Hosp Psychiatry* 2014;36(5):539-44. doi: 10.1016/j.genhosppsych.2014.05.021 [published Online First: 2014/07/16]

31. Yu J, Coons SJ, Draugalis JR, et al. Equivalence of Chinese and US-English versions of the SF-36 health survey. *Qual Life Res* 2003;12(4):449-57. doi: 10.1023/a:1023446110727 [published Online First: 2003/06/12]

Figure 1. Flowchart of the study protocol.



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SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description	
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	Pg.1, line 1-2
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	Pg.2, line 20
	2b	All items from the World Health Organization Trial Registration Data Set	N/A (clinicaltrials.gov)
Protocol version	3	Date and version identifier	Pg.2, line 21
Funding	4	Sources and types of financial, material, and other support	Pg 15, line 9-11
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	Pg.1, line 3-7, Pg. 15, line 1-3
	5b	Name and contact information for the trial sponsor	Pg.15, line 12-13
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	Pg.15, line 12-13

	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	N/A
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	Pg 4, line 8-27; Pg 5, line 1-14;
	6b	Explanation for choice of comparators	Pg.4, line 10-11; Pg.5, line 10-14;
Objectives	7	Specific objectives or hypotheses	Pg.5, line 17-20
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	Pg.6, line 3. Pg.11, line 6.
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	Pg 6, line 3-4.
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	Pg.6, line 9 to Pg.7, line 1;
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	Pg.7, line 3 to Pg.9, line 4
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	Pg.14, line 6-8.

	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	Pg.12, line 3-5
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	Pg.6, line 18-19
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	Pg.9, line 6 -14
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	Pg.9, line 17-20, Table 1
Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	Pg.10, line 4-8
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	Pg.10, line 10 to Pg. 11, line 3
Methods: Assignment of interventions (for controlled trials)			
Allocation:			
Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	Pg.11, line 6-7
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	Pg.11, line 7-11

Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	Pg.11, line 6-11
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	Pg.11, line 14-24
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	Pg.11, line 22
Methods: Data collection, management, and analysis			
Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	Pg.12 line 2-6, Pg. 9, line 10-14
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	Pg. 12, line 5-6
Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	Pg.12, line 9-11
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	Pg.12, line 14 to Pg.13, line 2
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	N/A
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	Pg.12, line 14,24-27
Methods: Monitoring			

Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	Pg.13, line 5-7
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	Pg.13, line 7-9
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	Pg.13, line 11-14
Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	Pg.13, line 7
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	Pg. 14, line 2
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	Pg.14, line 5-6
Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	Pg.14, line 3-6
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	N/A
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	Pg. 14, line 10-12

Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	Pg.16, line 6
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	Pg.14, line 13-15
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	Pg.14, line 15-17
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting results databases, or other data sharing arrangements), including any publication restrictions	Pg.14, line 17-18
	31b	Authorship eligibility guidelines and any intended use of professional writers	Pg.14, line 19-20
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	N/A
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	Supplement file 2
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	N/A

*It is strongly recommended that this checklist be read in conjunction with the SPIRIT 2013 Explanation & Elaboration for important clarification on the items. Amendments to the protocol should be tracked and dated. The SPIRIT checklist is copyrighted by the SPIRIT Group under the Creative Commons "Attribution-NonCommercial-NoDerivs 3.0 Unported" license.

Patient Information Sheet

Project title: Ultrasound-guided pulsed radiofrequency versus dry needling for pain management in chronic neck and shoulder myofascial pain patients: a randomized controlled trial

Researcher's name: Dr. Jin Wang

Research location: Peking Union Medical College Hospital

Who and how to contact when there is an emergency or disorder associated with research:

Dr Jin Wang Tel. +86 15210424157

Dr Xulei Cui Tel. +86 13717739381

Sponsor for this research:

1. Bethune Charitable Foundation "Beien" Funding (bnmr-2021-009)
2. Peking Union Medical College Hospital High-level Hospital Clinical Research Funding (2022-PUMCH-B-007)

Project Background

Chronic myofascial pain is a common chronic pain disease that affects as many as 85% of the general population. Dry needling and pulsed radiofrequency are two effective treatment methods for chronic myofascial pain. Dry needling is the use of a thin needle to repeatedly puncture the pain region to alleviate muscle pain. Potential mechanisms may involve changes of local electrical activity and chemokines, as well as modulation of peripheral and central sensitization processes. Pulsed radiofrequency is the use of a needle-introduced electrode to generate an electronic field at the pain region, which will elicit an analgesic effect via neuromodulation. Both treatments have shown effective analgesic effects in the short term, however, there is currently lacking strong evidence on their median to long-term analgesic effects, and on which treatment shows better analgesic effect.

Objective

To compare the treatment effects of pulsed radiofrequency and dry needling in chronic neck, shoulder, and upper back myofascial pain patients.

Details to be treated with research participants

After receiving information about the project details, the participants sign the documents, and consent to participate in this research. Then, research assistants will conduct interviews to collect baseline information about the participants. The baseline information mainly includes the participants' age, gender, BMI, history of comorbid disease, characteristics of pain, medical scale scores on pain, emotion, sleep, and quality of life. After that,

participants will be randomized to one of the two treatment groups and receive corresponding treatment every week for four weeks. The treatment process conforms to routine clinical practice, and participation of the study will not bring additional risks. After completion of treatment, participants will come back for follow-up visits at 1, 3, and 6 months. During follow-up, the clinicians will re-evaluate the participants' pain, emotion, sleep, and quality of life status using the scales same as the baseline evaluation.

Benefits to the research participants

Participants will receive good postoperative follow-up and medical support during the follow-up period.

Side effects for the participants

This study does not bring any additional side effects other than that of the two treatments themselves. There may be minor hemorrhage, infection, and pneumothorax, but the likelihood of occurrence is low because the treatment will be provided by experienced clinicians under ultrasound guidance and strict sterilization. We will follow the routine clinical management protocol if any adverse event happens.

Confidentiality

The data will be collected with confidentiality. No name or number of hospital records will be collected. The data will be presented as a whole without individual identification. Only researchers will have access to information. This study will inform patients that they are in research and able to decide whether to join or not. Patients can withdraw from the research at any time and it does not affect the treatment of the patient in any way.

Informed Consent Form

Project title: Ultrasound-guided pulsed radiofrequency versus dry needling for pain management in chronic neck and shoulder myofascial pain patients: a randomized controlled trial

Researcher's name: Dr. Jin Wang

Name of research participant _____

Age _____ **Medical record number** _____

Research Participant Consent

I, Mr./Mrs./Ms. _____ have known the details of the research project as well as the benefits and the risks that will arise to me from the research clearly and consent to be involved in the above research project. And I know that if there is any problem or question I could ask the researchers. Also, I could quit this research project at any time, without affecting the treatment that I deserve. In addition, the researchers will keep the specific information about me confidential and will only disclose it in the form of a summary of the research. Disclosure of information about me to relevant agencies could only be done in cases of necessity for academic reasons.

Signed _____

Date _____

Description of the doctor or researcher

I have explained the details of the project as well as the benefits of research and the potential risks were known to the participants without any hidden objection.

Signed _____

Date _____