Research Progress of Pulsed Radiofrequency in the Treatment of Shoulder Pain

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Abstract: The shoulder is one of the most complex anatomical structures in the body, consisting of bones, muscles, tendons, bursae, joint capsules, nerves, and blood vessels. Shoulder pain is one of the most common musculoskeletal syndromes clinically, according to statistics, the prevalence of shoulder pain in the adult population is 11% to 27%, lifetime prevalence as high as 67%. There are also significant differences in the prevalence of shoulder pain across age and gender. Typically, shoulder pain stems from trauma, degeneration, inflammation, vascular disease, and referred pain from other parts of the head, neck, and hands. Studies have shown that in addition to personal risk factors such as age, arthritis, obesity, diabetes, and thyroid disease, external factors such as living and working environments can lead to varying degrees of pain, limited mobility, and dysfunction in the shoulder, It imposes a huge economic burden on social development and healthcare services.
***Keywords*:** pulsed radiofrequency, shoulder pain, treatment

1. Introduction

Pulsed Radiofrequency (PRF) is a non-invasive neuromodulation technique widely used in pain management to relieve pain by sending intermittent, short-duration high-frequency alternating current (HFAC) to nerve tissues in order to alter nerve cell excitability and conductivity[1-8]60-83 years. In recent years, PRF technology has been widely used and researched in the treatment of shoulder pain. Data from several clinical trials have shown that PRF treatment for patients with shoulder pain can effectively reduce their symptoms, and has the advantages of long analgesic time, low anesthetic dosage and no obvious complications[9–11]60-83 years. Therefore, this article reviews the current research status and the latest progress of PRF technology for the treatment of shoulder pain, with a view to providing a solid theoretical basis for its clinical application.

2. Current status of shoulder pain diagnosis and treatment

In clinical practice, any injury to shoulder structures or underlying pathologic changes may cause acute or chronic pain in the shoulder[12,13]and has a protracted clinical course, which can be frustrating for patients as well as health-care professionals. Frozen shoulder is characterized by fibroproliferative tissue fibrosis, whereby fibroblasts, producing predominantly type I and type III collagen, transform into myofibroblasts (a smooth muscle phenotype, and cause patients to be limited in their daily activities[14]. The diagnosis of shoulder pain requires a combination of the patient's medical history, physical examination, and relevant ancillary tests in order to comprehensively aAssess the anatomical structure, functional status, and pathologic changes of his or her shoulder. Currently, common clinical interventions for the treatment of shoulder pain include oral medications, physical therapy, surgery, and local injections[15]. Although these treatments can reduce the patient's pain to some extent, they may also cause numerous adverse reactions in the patient. The use of Nonsteroidal Antiinflammatory Drugs (NSAIDs) may cause gastrointestinal damage, cardiovascular complications, renal impairment and other adverse effects[16]to perform a cost analysis of the 2 injections.\nDATA SOURCES: MEDLINE, SPORTDiscus, CINAHL, Embase, Web of Science, and SCOPUS databases were searched for randomized controlled trials using several keywords.\nSTUDY SELECTION: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA;In patients with massive rotator cuff tears, surgery may exacerbate anterosuperior subluxation of the humeral head, among other things[9]60-83 years. Therefore, there is an urgent need to develop safer and more effective treatments.

3. Analgesic mechanism of PRF technique

Although the use of PRF technology for the treatment of pain has received widespread attention from clinicians and researchers, there is still a great deal of controversy about the mechanism of action of PRF for the treatment of pain. For example, Erdine et al.[17]found that PRF caused microdamage to sensory nerve fibers (e.g., class C nerve fibers, A-β nerve fibers) at the lesion site through the electromagnetic field it generated; Smith et al.[18] reported that when PRF intervention generates heat between 45 °C and 85 °C in the target tissue, thermal damage to the nerve matrix destroys both myelinated and unmyelinated nerve fibers, which in turn attenuates the transmission of pain signals. However, other studies have shown that the analgesic effect of the PRF technique is not dependent on nerve injury[19,20], but rather is related to structural changes in nerve tissue. For example, several scholars have successively proposed that the PRF technique may hinder pain signaling by modulating the structure of synapses or class C nerve fibers responsible for pain and temperature sensation[21,22].

In addition, suppression of the inflammatory response is also considered to be one of the important ways in which the PRF technique exerts its analgesic effect. For example, in 2016, a clinical study by Yuan et al.[23]found that PRF intervention significantly reduced the levels of inflammatory factors such as Interleukin-6 (IL-1), Metalloproteinases (MMP-3), and Tumor necrosis factor-alpha (TNF-alpha) in the joint fluid of patients with severe osteoarthritis (OA), thereby alleviating joint pain symptoms. However, the basic study by Choi et al.[24]found that pro-inflammatory factors such as TNF-α and interleukin-6 (IL-6) were significantly up-regulated in rat peripheral nerve tissues in a rat model of selective injury to the sciatic nerve branches treated with PRF, which was hypothesized to be a possible difference between the different models. Scholars supporting this mechanism generally agree that the PRF technique modulates the function of the body's nervous system, mainly by adjusting the metabolic and endocrine levels of neural tissues, and improves pain-related inflammatory and immune responses, thus reducing pain [25].

4. Application of PRF technique in shoulder pain management

Since the first clinical application of PRF technology in the treatment of shoulder pain[26]chemical, cryogenic, or thermal means may be considered as an option on seldom occasions, because of the risk of neuritis and deafferentation pain, motor deficit, and potential unintentional damage to nontargeted tissue. To our knowledge, there is only 1 report concerning selective radiofrequency (RF, over the past two decades, studies have examined the efficacy of PRF technology in the treatment of shoulder pain, finding that it is both highly efficacious and low-risk. Therefore, the following is a review of studies related to PRF technology in the treatment of different types of shoulder pain, with the aim of promoting the clinical application and basic research of PRF technology in the future.

4.1 Studies related to the PRF technique in the treatment of periarthritis of the shoulder

Scapulohumeral periarthritis, it is characterized by the fact that in the presence of unknown intrinsic shoulder disease patients usually perceive insidious stiffness and limitation of active and passive shoulder motion and increased shoulder pain in the evening[27,28]. Rinoo V et al.[29]found that fluoroscopic device-guided PRF treatment of the suprascapular nerve in patients with frozen shoulder resulted in long-term relief of shoulder pain and improvement of their shoulder joint function. However, the guidance devices have the potential to increase radiation exposure to patients and staff, resulting in fewer studies being conducted. It was not until 2010 that Huang et al. [30] proposed to guide the PRF technique through radiation-free ultrasound for the treatment of frozen shoulder. Their study reported that under ultrasound guidance, the PRF technique resulted in effective relief of pain symptoms in two patients with frozen shoulder. Since then, Yan et al.[31] also conducted a randomized controlled pilot study of ultrasound-guided PRF for the treatment of frozen shoulder in 2019 and found that patients' NRS (Numeric Rating Scale) scores were significantly reduced, which further confirmed that the PRF technique has a significant inhibitory effect on shoulder pain. In summary, the use of PRF technology in the treatment of frozen shoulder has become more mature in clinical practice, and its therapeutic effect is more significant compared with that of traditional treatment methods[10].

4.2 Related studies on PRF technology in the treatment of shoulder impingement syndrome

The pathologic mechanism of shoulder impingement syndrome is the narrowing of the subacromial space structure, which results in mechanical impingement stimulation of the soft tissues in the shoulder joint region during shoulder movement, leading to the emergence of a variety of shoulder problems, such as shoulder pain on the affected shoulder when the patient is lying on the side and limitation of over-the-head movement[32,33]. Conservative treatments such as physiotherapy are often chosen by patients [33–35], but patients who do not respond to prolonged conservative treatment or who have severe injuries usually require surgical treatment[9]. In 2017, Okmen BM et al.[36]treated patients with shoulder impingement syndrome with PRF through the suprascapular nerve for two weeks and found that patients' VAS, Shoulder Pain and Disability Index (SPADI), and Nottingham Health Profile (NHP) scores were significantly lower compared to pre-treatment, indicating that PRF was effective in improving shoulder pain and function in patients. On this basis, Ergonenc et al.[37] extended the follow-up period (6 months) to observe the therapeutic effects of the PRF technique and found that the PRF intervention was effective in relieving symptoms and significantly improving shoulder motion in patients with chronic shoulder pain. The above studies demonstrate the effectiveness of the PRF technique in relieving shoulder pain in patients with shoulder impingement syndrome and its potential in the future clinical management of shoulder impingement syndrome.

4.3 Studies related to PRF technique in the treatment of rotator cuff injuries

Rotator cuff injuries are one of the most common triggers of shoulder pain, and many patients around the globe visit hospitals every year for rotator cuff injuries [33]. In 2008, Kane TP et al.[9]found the PRF technique to be an effective treatment for patients with end-stage pain from rotator cuff tear arthropathy by using PRF in 12 patients with rotator cuff tears. Sir E et al.[38]treated 31 patients with partial rotator cuff tears with PRF and evaluated the patients using NRS, SPADI and Likert scores during a 6-month follow-up period and found that the patients' shoulder pain and function improved after treatment. However, both of these clinical trials lacked control groups and had low clinical credibility. The above study suggests that PRF is an effective technique for relieving pain and improving shoulder function in patients with rotator cuff injuries, and has an impressive duration of effectiveness (up to 6 months). However, there is insufficient evidence to suggest that the PRF technique is superior to other techniques in improving pain and function in patients with rotator cuff injuries, and there is still a lack of extensive randomized controlled trials to support and confirm the advantages of PRF treatment techniques in the field of analgesia.

4.4 Studies Related to PRF Technique in the Treatment of Hemiplegic Shoulder Pain

Hemiplegic shoulder pain is a general term for shoulder pain on the hemiplegic side of stroke patients, which may involve different underlying pathogenetic mechanisms, such as: shoulder subluxation, shoulder-hand syndrome, increased dystonia, frozen shoulder, and brachial plexus nerve injuries, which contributes to the difficulty in diagnosing and treating hemiplegic shoulder pain [39,40]. Currently, common clinical treatments for hemiplegic shoulder pain include kinesiology taping [41], botulinum toxin A (BTX-A)[42], electrical nerve stimulation [43], and acupuncture [44]. In recent years, PRF technology has also been progressively used in the treatment of hemiplegic shoulder pain. Kim TH et al.[45]conducted a randomized controlled trial of PRF treatment in 20 patients with hemiplegic shoulder pain, and significant improvements in pain and shoulder mobility assessment were observed in both groups compared to preoperative levels. Although the therapeutic efficacy of the PRF technique was weaker than that of injecting corticosteroids directly into the joint, the PRF technique reduces the risk of complications due to the injected medication. However, there are no related studies to explore whether the minor damage of nerve fibers caused by PRF will have adverse effects on hemiplegic patients. A large number of clinical studies of PRF in the treatment of hemiplegic shoulder pain are needed in the future. In addition, the TPRF (electrode electrode) technology developed from the classical PRF technology (needle electrode) may be an ideal scheme for the treatment of hemiplegic shoulder pain, which avoids the injury caused by puncture to hemiplegic patients, has the advantages of non-invasive and simple operation, and has a good effect on relieving chronic shoulder pain[46]. However, whether TPRF technology can relieve hemiplegic shoulder pain has not been reported, so it is worthy of in-depth research and exploration.

5. Reflections on the optimization of PRF technology

Although the PRF technique has been widely used in the treatment of shoulder pain, PRF still reveals many problems during clinical practice. On the one hand, the delivery route of PRF treatment needs to be further optimized. Although other fluoroscopic devices are currently replaced by ultrasound guidance to reduce the impact of radiation on both patients and doctors, puncture-based PRF still has drawbacks such as difficulty in carrying, triggering trauma, and the need for sedation [10,31,36,37]. In 2010, Taverner MG et al.[47]first proposed the use of TPRF for the treatment of knee pain by placing electrode pads in the patient's painful area and applying a specific pulse frequency to deliver electrical stimulation, which in turn circumvents the trauma to the patient caused by puncture-type PRF. Since then, studies have begun to apply TPRF to the treatment of shoulder pain and have found that TPRF interventions can significantly alleviate the discomfort of patients with shoulder pain, and that TPRF treatment has the advantages of good efficacy, low trauma, low pain, and high portability compared with PRF and TENS techniques [46,48–50]. However, due to the resistive properties of human skin, TPRF therapy requires a stronger voltage to deliver electrical stimulation, and there may be excessive voltage that can cause safety hazards. In conclusion, PRF treatment, either by puncture or electrode pads, is effective in relieving shoulder pain, and it is unclear how these two treatment modalities are superior or inferior in treating patients with the same type of shoulder pain, and more trials are needed to clarify their roles and differences.

On the other hand, the selection of PRF therapeutic targets should be careful. The posterior and superior regions of the shoulder are sensed by sensory nerve fibers of the suprascapular nerve[51,52] ; sensation in the anterior and inferior regions of the shoulder, innervated by sensory nerve fibers from associated nerves such as the axillary nerve[53,54]. Currently, most PRF treatments are used to control pain by intervening on a patient's suprascapular nerve, and few studies have examined PRF intervention on the axillary nerve. It was not until 2012 that the first study found a significant reduction in shoulder pain in patients at the end of treatment by intervening with PRF on the suprascapular and axillary nerves[54]. Because the trial was a case report, it was not sufficient to demonstrate that simultaneous PRF treatment of the suprascapular and axillary nerves in patients with shoulder pain is safe and feasible. In 2020, Yang et al.[55]targeted the suprascapular and axillary nerves in patients with hemiplegic shoulder pain and conducted a randomized controlled trial of PRF treatment, finding that the technique improved both pain and function in patients. Depending on the location or different diseases causing shoulder pain, the choice of axillary or suprascapular nerves for intervention may further enhance the efficacy of the PRF technique.

6. Summary and Outlook

From the available evidence, PRF technology opens new doors for treatment in the field of pain. However, there are still many doubts about PRF technology in the treatment of shoulder pain. Subsequently, there is still a need to carry out a large number of clinical trials and basic experiments to explore the mechanism, effect and safety of PRF technology in the treatment of shoulder pain, and more high-quality randomized controlled trials should be encouraged to optimize the optimal parameters and implementation pathway of PRF for the treatment of patients with shoulder pain, so as to allow this technology to better serve the clinical practice.

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References

[1] Nazari G, MacDermid J C, Bryant D, et al.. The effectiveness of surgical vs conservative interventions on pain and function in patients with shoulder impingement syndrome. A systematic review and meta-analysis[J]. PloS One, 2019, 14(5): e0216961.
[2] Hodgetts C J, Leboeuf-Yde C, Beynon A, et al.. Shoulder pain prevalence by age and within occupational groups: a systematic review[J]. Archives of Physiotherapy, 2021, 11: 24.
[3] Djade C D, Porgo T V, Zomahoun H T V, et al.. Incidence of shoulder pain in 40 years old and over and associated factors: A systematic review[J]. European Journal of Pain (London, England), 2020, 24(1): 39–50.
[4] Lucas J, van Doorn P, Hegedus E, et al.. A systematic review of the global prevalence and incidence of shoulder pain[J]. BMC Musculoskeletal Disorders, 2022, 23: 1073.
[5] Abdelshafi M E, Yosry M, Elmulla A F, et al.. Relief of chronic shoulder pain: a comparative study of three approaches[J]. Middle East Journal of Anaesthesiology, 2011, 21(1): 83–92.
[6] Dzakpasu F Q S, Carver A, Brakenridge C J, et al.. Musculoskeletal pain and sedentary behaviour in occupational and non-occupational settings: a systematic review with meta-analysis[J]. The International Journal of Behavioral Nutrition and Physical Activity, 2021, 18(1): 159.
[7] Wright J O, Wiggins W, Smith M S, et al.. Shoulder Pain and Dysfunction After Vaccination: A Systematic Review[J]. JBJS reviews, 2023, 11(1).
[8] Giacalone A, Alessandria P, Ruberti E. The Physiotherapy Intervention for Shoulder Pain in Patients Treated for Breast Cancer: Systematic Review[J]. Cureus, 2019, 11(12): e6416.
[9] Kane T P C, Rogers P, Hazelgrove J, et al.. Pulsed radiofrequency applied to the suprascapular nerve in painful cuff tear arthropathy[J]. Journal of Shoulder and Elbow Surgery, 2008, 17(3): 436–440.
[10] Wu Y-T, Ho C-W, Chen Y-L, et al.. Ultrasound-guided pulsed radiofrequency stimulation of the suprascapular nerve for adhesive capsulitis: a prospective, randomized, controlled trial[J]. Anesthesia and Analgesia, 2014, 119(3): 686–692.
[11] M G, Ce R-G, Br T, et al.. Pulsed radiofrequency of suprascapular nerve for chronic shoulder pain: a randomized double-blind active placebo-controlled study[J]. Pain practice : the official journal of World Institute of Pain, Pain Pract, 2013, 13(2).
[12] Millar N L, Meakins A, Struyf F, et al.. Frozen shoulder[J]. Nature Reviews. Disease Primers, 2022, 8(1): 59.
[13] Hoppe M W, Brochhagen J, Tischer T, et al.. Risk factors and prevention strategies for shoulder injuries in overhead sports: an updated systematic review[J]. Journal of Experimental Orthopaedics, 2022, 9(1): 78.
[14] Sergienko S, Kalichman L. Myofascial origin of shoulder pain: a literature review[J]. Journal of Bodywork and Movement Therapies, 2015, 19(1): 91–101.
[15] Lowry V, Lavigne P, Zidarov D, et al.. A Systematic Review of Clinical Practice Guidelines on the Diagnosis and Man-

agement of Various Shoulder Disorders[J]. Archives of Physical Medicine and Rehabilitation, 2024, 105(2): 411–426.
[16] Ziradkar R, Best T M, Quintero D, et al.. Nonsteroidal Anti-inflammatory and Corticosteroid Injections for Shoulder Impingement Syndrome: A Systematic Review and Meta-analysis[J]. Sports Health, 2023, 15(4): 579–591.
[17] Erdine S, Bilir A, Cosman E R, et al.. Ultrastructural changes in axons following exposure to pulsed radiofrequency fields[J]. Pain Practice: The Official Journal of World Institute of Pain, 2009, 9(6): 407–417.
[18] Hp S, Jm M, Vr C. Radiofrequency neurolysis in a clinical model. Neuropathological correlation[J]. Journal of neurosurgery, J Neurosurg, 1981, 55(2).
[19] Protasoni M, Reguzzoni M, Sangiorgi S, et al.. Pulsed radiofrequency effects on the lumbar ganglion of the rat dorsal root: a morphological light and transmission electron microscopy study at acute stage[J]. European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 2009, 18(4): 473–478.
[20] Tun K, Cemil B, Gurcay A G, et al.. Ultrastructural evaluation of Pulsed Radiofrequency and Conventional Radiofrequency lesions in rat sciatic nerve[J]. Surgical Neurology, 2009, 72(5): 496–500; discussion 501.
[21] Chua N H L, Vissers K C, Sluijter M E. Pulsed radiofrequency treatment in interventional pain management: mechanisms and potential indications-a review[J]. Acta Neurochirurgica, 2011, 153(4): 763–771.
[22] Ørstavik K, Weidner C, Schmidt R, et al.. Pathological C-fibres in patients with a chronic painful condition[J]. Brain: A Journal of Neurology, 2003, 126(Pt 3): 567–578.
[23] Yuan Y, Shen W, Han Q, et al.. Clinical observation of pulsed radiofrequency in treatment of knee osteoarthritis[J]. Int. J. Clin. Exp. Med, 2016, 9:20050–20055.
[24] Choi S, Choi H J, Cheong Y, et al.. Internal-specific morphological analysis of sciatic nerve fibers in a radiofrequency-induced animal neuropathic pain model[J]. PloS One, 2013, 8(9): e73913.
[25] Van Zundert J, Patijn J, Kessels A, et al.. Pulsed radiofrequency adjacent to the cervical dorsal root ganglion in chronic cervical radicular pain: a double blind sham controlled randomized clinical trial[J]. Pain, 2007, 127(1–2): 173–182.
[26] Rohof O J J M. Radiofrequency treatment of peripheral nerves[J]. Pain Practice: The Official Journal of World Institute of Pain, 2002, 2(3): 257–260.
[27] S B, A V, M F, et al.. Idiopathic adhesive capsulitis of the shoulder: a review[J]. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA, Knee Surg Sports Traumatol Arthrosc, 2007, 15(8).
[28] Jd Z, A R. Frozen shoulder: a consensus definition[J]. Journal of shoulder and elbow surgery, J Shoulder Elbow Surg, 2011, 20(2).
[29] Shah R V, Racz G B. Pulsed mode radiofrequency lesioning of the suprascapular nerve for the treatment of chronic shoulder pain[J]. Pain Physician, 2003, 6(4): 503–506.
[30] Huang C-C, Tsao S-L, Cheng C-Y, et al.. Treating frozen shoulder with ultrasound-guided pulsed mode radiofrequency lesioning of the suprascapular nerve: two cases[J]. Pain Medicine (Malden, Mass.), 2010, 11(12): 1837–1840.
[31] Yan J, Zhang X-M. A randomized controlled trial of ultrasound-guided pulsed radiofrequency for patients with frozen shoulder[J]. Medicine, 2019, 98(1): e13917.
[32] Chang W K. Shoulder impingement syndrome[J]. Physical Medicine and Rehabilitation Clinics of North America, 2004, 15(2): 493–510.
[33] Garving C, Jakob S, Bauer I, et al.. Impingement Syndrome of the Shoulder[J]. Deutsches Arzteblatt International, 2017, 114(45): 765–776.
[34] Heron S R, Woby S R, Thompson D P. Comparison of three types of exercise in the treatment of rotator cuff tendinopathy/shoulder impingement syndrome: A randomized controlled trial[J]. Physiotherapy, 2017, 103(2): 167–173.
[35] Gunay Ucurum S, Kaya D O, Kayali Y, et al.. Comparison of different electrotherapy methods and exercise therapy in shoulder impingement syndrome: A prospective randomized controlled trial[J]. Acta Orthopaedica Et Traumatologica Turcica, 2018, 52(4): 249–255.
[36] Ökmen B M, Ökmen K. Comparison of photobiomodulation therapy and suprascapular nerve-pulsed radiofrequency in chronic shoulder pain: a randomized controlled, single-blind, clinical trial[J]. Lasers in Medical Science, 2017, 32(8): 1719–1726.
[37] Ergonenc T, Beyaz S G. Effects of ultrasound-guided suprascapular nerve pulsed radiofrequency on chronic shoulder pain[J]. Medical Ultrasonography, 2018, 20(4): 461–466.
[38] Sir E, Eksert S. Ultrasound-guided pulsed radiofrequency neuromodulation of the suprascapular nerve in partial rotator cuff tears[J]. Turkish Journal of Medical Sciences, 2019, 49(5): 1524–1528.
[39] Kalichman L, Ratmansky M. Underlying pathology and associated factors of hemiplegic shoulder pain[J]. American Journal of Physical Medicine & Rehabilitation, 2011, 90(9): 768–780.
[40] Wilson R D, Chae J. Hemiplegic Shoulder Pain[J]. Physical Medicine and Rehabilitation Clinics of North America, 2015, 26(4): 641–655.
[41] Wang Y, Li X, Sun C, et al.. Effectiveness of kinesiology taping on the functions of upper limbs in patients with stroke: a meta-analysis of randomized trial[J]. Neurological Sciences: Official Journal of the Italian Neurological Society and

of the Italian Society of Clinical Neurophysiology, 2022, 43(7): 4145–4156.
[42] Xie H-M, Guo T-T, Sun X, et al.. Effectiveness of Botulinum Toxin A in Treatment of Hemiplegic Shoulder Pain: A Systematic Review and Meta-analysis[J]. Archives of Physical Medicine and Rehabilitation, 2021, 102(9): 1775–1787.
[43] Mazzola A, Spinner D. Ultrasound-Guided Peripheral Nerve Stimulation for Shoulder Pain: Anatomic Review and Assessment of the Current Clinical Evidence[J]. Pain Physician, 2020, 23(5): E461–E474.
[44] Zhan J, Luo Y, Mao W, et al.. Efficacy of acupuncture versus rehabilitation therapy on post-stroke shoulder pain: A systematic review and meta-analysis of randomized controlled trials[J]. Medicine, 2023, 102(29): e34266.
[45] Kim T H, Chang M C. Comparison of the effectiveness of pulsed radiofrequency of the suprascapular nerve and intra-articular corticosteroid injection for hemiplegic shoulder pain management[J]. Journal of Integrative Neuroscience, 2021, 20(3): 687–693.
[46] Lin M-L, Chiu H-W, Shih Z-M, et al.. Two Transcutaneous Stimulation Techniques in Shoulder Pain: Transcutaneous Pulsed Radiofrequency (TPRF) versus Transcutaneous Electrical Nerve Stimulation (TENS): A Comparative Pilot Study[J]. Pain Research & Management, 2019, 2019: 2823401.
[47] Taverner M G, Ward T L, Loughnan T E. Transcutaneous pulsed radiofrequency treatment in patients with painful knee awaiting total knee joint replacement[J]. The Clinical Journal of Pain, 2010, 26(5): 429–432.
[48] Taverner M G, Loughnan T E, Soon C-W I. Transcutaneous application of pulsed radiofrequency treatment for shoulder pain[J]. Pain Practice: The Official Journal of World Institute of Pain, 2013, 13(4): 310–315.
[49] Taverner M, Loughnan T. Transcutaneous pulsed radiofrequency treatment for patients with shoulder pain booked for surgery: a double-blind, randomized controlled trial[J]. Pain Practice: The Official Journal of World Institute of Pain, 2014, 14(2): 101–108.
[50] Balogh S E. Transcutaneous application of pulsed radiofrequency: four case reports[J]. Pain Practice: The Official Journal of World Institute of Pain, 2004, 4(4): 310–313.
[51] Brown D E, James D C, Roy S. Pain relief by suprascapular nerve block in gleno-humeral arthritis[J]. Scandinavian Journal of Rheumatology, 1988, 17(5): 411–415.
[52] Laumonerie P, Dalmas Y, Tibbo M E, et al.. Sensory innervation of the human shoulder joint: the three bridges to break[J]. Journal of Shoulder and Elbow Surgery, 2020, 29(12): e499–e507.
[53] Esparza-Miñana J M, Mazzinari G. Adaptation of an Ultrasound-Guided Technique for Pulsed Radiofrequency on Axillary and Suprascapular Nerves in the Treatment of Shoulder Pain[J]. Pain Medicine (Malden, Mass.), 2019, 20(8): 1547–1550.
[54] Kim J S, Nahm F S, Choi E J, et al.. Pulsed radiofrequency lesioning of the axillary and suprascapular nerve in calcific tendinitis[J]. The Korean Journal of Pain, 2012, 25(1): 60–64.
[55] Yang C, Xu H, Wang R, et al.. The management of hemiplegic shoulder pain in stroke subjects undergoing pulsed radiofrequency treatment of the suprascapular and axillary nerves: a pilot study[J]. Annals of Palliative Medicine, 2020, 9(5): 3357–3365.