Ultrasound-guided pulsed radiofrequency neuromodulation of the suprascapular nerve in partial rotator cuff tears

Abstract

Background/Aim: Pulsed radiofrequency (PRF) of the suprascapular nerve has shown to be effective in the treatment of chronic shoulder pain. Ultrasound guidance has gained popularity in regional blocks recently. This study aimed to investigate the efficacy of suprascapular nerve pulsed radiofrequency under the guidance of ultrasonography.

Materials and Methods: This retrospective study included patients treated with PRF of the suprascapular nerve with a diagnosis of partial rotator cuff tears. The patients were assessed with a numeric rating scale (NRS), shoulder pain and disability index (SPADI), Likert patient satisfaction score before the treatment, and three weeks, and six months following the treatment.

Results: A total of 31 patients was included in the study. The patients’ mean age was 66.8 ± 13.3 years. The mean scores of NRS, SPADI, and Likert scores before the procedure (7.32 ± 1.1, 69.0 ± 8.5, 1.6 ± 0.6), at three weeks (2.9 ± 2.1, 32.1 ± 17.20, 4 ± 1.2), and six months (3.2± 2.6, 33.9 ± 20.8, 3.8 ± 1.2) after the procedure were evaluated. We observed significant improvement in NRS, SPADI, and Likert scores at three weeks and six months following the treatment (p<0.001).

Conclusions: The study demonstrated that US-guided suprascapular nerve PRF achieves good pain relief and functional improvement in patients with partial rotator cuff tears for at least six months.

Keywords: Pulsed radiofrequency treatment, rotator cuff injuries, ultrasonography, nerve block, shoulder pain
1. Introduction

Management of shoulder pain requires a multimodal and algorithmic approach, including the use of non-steroidal anti-inflammatory drugs (NSAID), physiotherapy, selective nerve interventions, and surgical procedures [1]. Generally, a suprascapular nerve block is administered first with local anesthetic agents and corticosteroids [2]. The technique is often useful for short-term, and repeated interventions are needed. Thus, the risk of nerve injury, infection, and side effects due to steroid use may increase [3]. Also, other therapeutic options, including neurolysis or neurectomy of the suprascapular nerve, may cause permanent paralysis of the supraspinatus and infraspinatus muscles [4].

Suprascapular nerve pulsed radiofrequency (PRF) neuromodulation, has emerged as an alternative intervention for pain control since 2002 and has been increasingly used to date [5]. Recent studies have reported that suprascapular nerve PRF under ultrasound (US) guidance provides direct visualization of the nerve, thereby allowing the more rapid onset of anesthesia [6, 7]. The main advantage of US-guided suprascapular nerve PRF over other pain management methods is that a single application provides long-term pain relief with a lesser incidence of neural trauma [4, 8, 9]. However, there are limited studies evaluating the usefulness of the procedure in partial rotator cuff tears under US guidance [10].

In this study, we aimed to investigate the efficacy of US-guided suprascapular nerve PRF on chronic shoulder pain and function in patients with partial rotator cuff lesions.

2. Materials and Method

2.1. Study design and study population
This retrospective study included 31 patients (24 women, 7 men) who underwent US-guided suprascapular nerve PRF between May 2016 and November 2018 and had shoulder pain for at least three months due to partial rotator cuff tear. Written informed consent was obtained from each patient. Patients’ data were obtained from patient files and follow-up forms. The Institutional Review Board approved the study protocol (2019/06, 19/71), and the study was conducted by the principles of the Declaration of Helsinki.

The inclusion criteria for the study were: refractory shoulder pain unresponsive to conservative therapies including paracetamol, NSAIDs, opioids, physiotherapy, intra-articular steroid injections, or combinations of these treatments, and radiologically proven partial tear of the rotator cuff.

Exclusion criteria included inflammatory arthritis, adhesive capsulitis, active synovitis of the shoulder joint, previous history of shoulder surgery, shoulder joint injection in the last one month, advanced osteoarthritis, neurologic conditions (hemiparesis, Parkinson’s disease etc.), current use of anticoagulant medications, and presence of complete tear of the rotator cuff.

All patients underwent shoulder radiography before the treatment, and the etiology of a partial tear of the rotator cuff was documented by magnetic resonance imaging (MRI) findings. A radiologist evaluated the MR images of the patients. MRI revealed muscle atrophy in six (19%) patients; nevertheless, the volume of muscle was larger than that of fat (muscle> fat). On the other hand, average muscle volume was observed in the remaining 25 (81%) patients. Humeral head migration and cysts were not observed in any patient.
Patients were evaluated using the Numeric Rating Scale (NRS) for pain, ranging from none (0) to extreme [10]. The Shoulder Pain and Disability Index (SPADI), a 13-item scale, was used to assess improvement in shoulder function [11]. A 5-point Likert scale, a subjective assessment method, was used to evaluate patient satisfaction. NRS, SPADI, and Likert measurements were performed before the treatment, at three weeks, and six months after the treatment.

2.2. Intervention

Two physicians experienced in US-guided suprascapular nerve injections performed the PRF procedures under local anesthesia in an operating room. After the patient placed in the sitting position, intravenous access was established, and routine monitoring (pulse oximetry, electrocardiogram, and non-invasive arterial pressure) was performed. Mild sedation was achieved with 2 mg intravenous midazolam bolus at a dose that did not impair the patient's consciousness. Chlorhexidine was used for skin antisepsis. The suprascapular notch and the advance of the needle to the suprascapular nerve were visualized by US (Edge, Sonosite, Bothell, WA, USA) with a high-frequency linear probe (HFL50xp, 15-6 MHz) (Figure 1.A, B). Skin anesthesia was achieved by administering 2% prilocaine through a 25 Gauge (G) needle. In-plane approach, a 22 G, 10 cm long, 5 mm active tip, echogenic radiofrequency (RF) cannula (EchoRF, Cosman, USA) introduced to the suprascapular notch (Figure 1.C). Motor stimulation performed with 2 Hz at a setting of 1 V, and the response was observed at the deltoid muscle. Subsequently, sensory stimulation was performed at 50 Hz at a setting of 0.5 V. Patients defined paresthesia, tingling, and pain in the deltoid and upper arm region. Accurate placement of the needle-tip was demonstrated via US. After negative aspiration of blood, 1 ml of
1% prilocaine injected. One minute after local anesthetic injection, pulsed RF was performed at 42°C for 360 seconds. Patients were followed-up in the postoperative care unit for 1 hour since post-procedure complications may develop.

2.3. Statistical analysis

After the data were transferred to the computer, the statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were defined as number, percentage, mean, standard deviation (SD), minimum, and maximum values. The consistency of continuous data to normal distribution was determined by the Kolmogorov Smirnov test. The Friedman test was used to compare continuous data in dependent triple groups that did not conform to normal distribution. Bonferroni corrected Wilcoxon test was used to determine which binary subgroup was the origin of the difference in the triple groups. In Bonferroni correction, the statistical significance level was accepted as $p < 0.017$. In other tests, a $p$-value of $< 0.05$ was considered significant.

3. Results

The present study included 31 shoulders of 31 patients who underwent US-guided pulsed radiofrequency (PRF) procedure of the suprascapular nerve. The mean age of the patients was $66.8 \pm 13.3$ years, and the mean body mass index (BMI) was $28.1 \pm 2.7$. The demographic and clinical characteristics of the patients included in the study were presented in Table 1.

Significant improvements in NRS and SPADI subscores were observed in the treated patients in the third week and sixth month after the procedure when compared to the pre-procedure ($p < 0.001$) (Table 2). In addition, no statistically significant difference was
observed between NRS and SPADI scores between three weeks and six months (p: 0.28, p:0.44). Based on results of the Likert Scale, suprascapular nerve PRF treatment resulted in good patient satisfaction in 71% patients (22 patients out of 31) at three weeks (p<0.001), and in 68% patients (21 out of 31) at six months (p<0.001) (Table 2) (Figure 2). No adverse effects or complications were observed throughout the follow-up period of six months.

4. Discussion

In this study, the efficacy of US-guided suprascapular nerve PRF treatment on chronic shoulder pain related to a partial rotator cuff tears was investigated. During the six-month follow-up period, most patients demonstrated good pain relief and improved shoulder functionality. To our knowledge, this is one of the few studies investigating the use of the US in the application of pulsed radiofrequency to the suprascapular nerve.

Along with the motor innervation of the infraspinatus and supraspinatus muscles, suprascapular nerve covers approximately 70% of the sensory innervation of the shoulder girdle, including the glenohumeral joint, capsule and acromioclavicular joint [12]. Correspondingly, an isolated blockade of the suprascapular nerve has demonstrated to be effective in pain relief after shoulder surgeries [13]. Suprascapular nerve block has been performed in joint pathologies, rotator cuff lesions, and other related conditions providing effective pain relief and functional improvement [13-16]. The use of PRF on peripheral nerves such as the suprascapular nerve has gained popularity in recent years owing to the non-destructive mechanism and low risk of complications. Although the mechanism of pain relief of PRF is not clearly understood, it has been proposed that an electrical field is generated at the tip of the needle that penetrates the nerve fibers and causes
physiological and ultrastructural changes in the nociceptive axons [17]. Another proposed
mechanism is that an increase in c-Fos production occurs in the posterior horn cells after
PRF, possibly affecting the C-fiber transmission by altering the activity of the sodium
channels [18, 19]. Thus, longer duration of pain relief can be achieved with this technique
compared to other treatment modalities such as injections of corticosteroids and local
anesthetic agents, and thermal lesioning [10].

In the literature, the first application of PRF to the suprascapular nerve was applied
by Rohof in 2002 with a blind technique [5]. Although the blind technique is still widely
used, it may cause catastrophic complications such as pneumothorax, especially in
patients with anatomical variations [20]. However, Gurbet et al. reported significant pain
relief and increase in shoulder function for at least three months after the blind technique
suprascapular PRF procedure without any severe complications [21]. Also, instead of
blind technique, fluoroscopy or computed tomography (CT) guided techniques have been
applied in PRF of the suprascapular nerve [22]. However, in US-guided procedures,
needle advancement is displayed in real time, thereby reducing the likelihood of damage
to nerves, vessels, and other adjacent structures [23-25]. Furthermore, when US is
compared with CT and fluoroscopy, US does not cause radiation exposure to the patient
or researcher, it is a portable device, and reduces the cost of the procedure [26].
Correspondingly, a trend towards US use has been observed in recent studies. Wu et al.
reported improved shoulder function and pain relief for at least 12 weeks after the US-
guided suprascapular nerve PRF procedure for adhesive capsulitis and concluded that
noticeable reduction in VAS score could be achieved as early as one week after the
procedure [14]. In a recent study, Ergonenc et al. performed US-guided suprascapular
PRF to 74 patients and achieved significant improvements in pain and functionality in the
majority of patients during the six-month follow-up period [8]. Therefore, US guidance was the preferred technique instead of fluoroscopy or CT guidance in this study. As a result, US-guided suprascapular nerve PRF showed significant improvement in shoulder pain and function through the six months follow-up period.

There were some limitations to our study. The study lacked a control group, and comparison of US-guided suprascapular nerve PRF with other treatment modalities was not possible. Although good results obtained at the end of the six-month follow-up, further studies are needed to evaluate the long-term effects of the US use on PRF application to the suprascapular nerve. Finally, due to the rigid inclusion criteria, the number of patients included in the current study was relatively small, and this may limit the generalizability of the results of the study.

5. Conclusion

The current study demonstrated that the US-guided suprascapular nerve PRF is a reliable technique in partial rotator cuff tears. Also, in the majority of patients, it provides adequate pain relief and an improvement in shoulder functions for at least six months. Furthermore, trained physicians can easily repeat this neuromodulation procedure in the case of recurrence of pain without any damage to the nerve and neighboring soft tissues under US guidance.

Conflict of interest

No potential conflict of interest relevant to this article was reported.
6. References


# Tables

**Table 1. Demographic Data**

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<td>Sex</td>
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<tr>
<td>Female</td>
<td>24 (77.4)</td>
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<td>Age (Years)</td>
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<td>Length (cm)</td>
<td>163.00 ± 6.85</td>
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<td>Weight (kg)</td>
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<td>BMI</td>
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Table 2. Numeric Rating Scale (NRS), Shoulder Pain and Disability Index (SPADI), Likert patient satisfaction scores before treatment and 3 weeks and 6 months after treatment

<table>
<thead>
<tr>
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<th>Mean±Std. Deviation</th>
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<tr>
<td>NRS</td>
<td>Before treatment</td>
<td>7,32±1,10</td>
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<td></td>
<td>3rd week</td>
<td>2,90±2,11</td>
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<tr>
<td></td>
<td>Before treatment</td>
<td>7,32±1,10</td>
</tr>
<tr>
<td></td>
<td>6th month</td>
<td>3,22±2,61</td>
</tr>
<tr>
<td></td>
<td>3rd week</td>
<td>2,90±2,11</td>
</tr>
<tr>
<td></td>
<td>6th month</td>
<td>3,22±2,61</td>
</tr>
<tr>
<td>SPADI</td>
<td>Before treatment</td>
<td>68,96±8,54</td>
</tr>
<tr>
<td></td>
<td>3rd week</td>
<td>32,09±17,20</td>
</tr>
<tr>
<td></td>
<td>Before treatment</td>
<td>68,96±8,54</td>
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<td></td>
<td>6th month</td>
<td>33,93±20,78</td>
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<td>32,09±17,20</td>
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<td>6th month</td>
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<td>Likert</td>
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<td>3rd week</td>
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<td></td>
<td>Before treatment</td>
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<tr>
<td></td>
<td>6th month</td>
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Figures and Figure Legends

Figure 1. A. The positioning of the linear ultrasound transducer and radiofrequency electrode, B. Scanning of the suprascapular nerve with linear ultrasound probe; trapezius muscle (TM), suprascapular muscle (SM), suprascapular notch, and color-doppler imaging of the suprascapular artery (SA), C. Real-time imaging of the needle insertion under ultrasonographic guidance.
Figure 2. Diagram of Numeric Rating Scale (NRS) (A), Shoulder Pain and Disability Index (SPADI) (B), and Likert patient satisfaction scores (C) before and after pulsed radiofrequency therapy.