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NEUROPATHIC PAIN (A ABD-ELSAYED, SECTION EDITOR)

Radiofrequency Ablation for Management of Shoulder Pain

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Abstract

Purpose of Review The treatment options for the management of shoulder pain are broad but evolving process. Modalities for controlling shoulder pain have commonly focused on pharmacotherapy, physical therapy, rehabilitation, and invasive procedures (surgical procedures, surgical, intra-articular steroid injections, many times, being sub-optimal). The use of radiofrequency ablation (RFA) for managing shoulder pain is on the rise. Our review investigated the evidence for the use of RFA in the management of shoulder pain.

Recent Findings In our investigation, a review of the literature was conducted using Medline, PubMed, and Cochrane Database of Systematic Reviews from 1966 to 2018. Our study included RCTs, open non-randomized control studies, prospective studies, retrospective studies, case series, and case reports. We limited our search to patients with chronic shoulder pathologies. Our initial search identified 96 articles for initial review. This was narrowed down to 31 articles, which met our inclusion criteria, with only 18 articles remaining after our exclusion criteria was applied.

Summary This systematic review suggests that shoulder RFA may provide a safe and significant benefit in the management of chronic shoulder pain. There were a few high-quality RCTs included in our study, which supports the findings of several case reports and case series.

Keywords RFA · Shoulder pain · PRFA · Chronic pain · Radiofrequency ablation · Pain management

Introduction

Shoulder pain is a fairly common musculoskeletal pathology, resulting in functional disability and decreased quality of life, reported as the second most common musculoskeletal disorder in adults over their lifetime, and affecting 15–30% of the adult population [1, 2]. Presentation is typically with pain of either acute, sub-acute, or chronic onset. Additionally, patients may also have associated decreased range of motion in the affected joint, ultimately affecting quality of life [1, 3, 4].

Management of shoulder pain is a multidisciplinary approach, including pharmacotherapy, physical therapy, rehabilitation, and more invasive procedures (surgical procedures, surgical, intra-articular steroid injections, regional anesthesia techniques, neurolysis (surgical, chemical, and radiofrequency) [5–10]).

Blockade of the suprascapular nerve (SSN), which supplies up to 70% of the innervation of the shoulder, is now commonly employed in the management of shoulder pain [11]. Various studies conducted continue to demonstrate the efficacy of pulsed radiofrequency (PRF) neuromodulation or radiofrequency ablation (RFA) of the SSN in the management of shoulder pain. Advantages of suprascapular nerve blockade (SSNB) using PRF include providing a longer-lasting duration of action, and lesioning is non-destructive to tissues [9, 12, 13]. Hence, it can be repeated more frequently, resulting in decreased analgesic use, increased patient satisfaction, reduced painful protective muscle spasms, long-lasting pain relief, and increased patient satisfaction [9, 12, 13].

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Several case reports, case series, and prospective and retrospective studies have been conducted to demonstrate the efficacy of PRF [7, 14–16]. This systematic review provides a summary of the evidence behind the use of RFA or PRF for the management of shoulder pain.

Methods

The authors searched Medline, PubMed, and Cochrane Database of Systematic Reviews on June 15, 2018. The following MeSH terms "radiofrequency ablation," "radiofrequency," "RF," "ablation," "neurolysis," "pulsed radiofrequency," "radiofrequency therapy," "shoulder pain," and "shoulder osteoarthritis" were searched. Bibliographies were screened for additional sources. We excluded papers that discussed: non-shoulder pathologies, animal studies, non-English papers, and non-RFA technologies. Our inclusion criteria include adults with shoulder pain, use of pulsed or continuous RFA, and original studies. Previously published review articles were also reviewed for additional sources (Fig. 1).

Inclusion and Exclusion Criteria

In the systematic review, RCTs, open non-randomized control studies, prospective studies, retrospective studies, case series, and case reports were included. We limited our search to patients with chronic shoulder pathologies. We excluded research that was available in abstract or poster form only, animal studies, non-English papers, pediatric studies, or employed non-radiofrequency-based technology.

Outcome

We included pain scores from studies that utilized a VAS (visual analog scale) score (VAS 0–10) or NRS (0–10). In addition, we evaluated functional or physical disability scores if they were available. We also evaluated changes in analgesic consumption. Adverse effects from RF ablation treatments were also recorded.

Data Extraction

The final evaluation included case reports, retrospective, prospective, and randomized controlled studies. The reference population, diagnostic group, and outcomes were used utilizing a standardized extraction form. The information extracted includes author's last name, publication year, study design, number of arms, sample size, ablation technique (pulsed vs. conventional), temperature range and duration, duration of pain relief, secondary outcomes, side effects, and significant conclusions. The mean pain scores were extracted when available (Table 1).

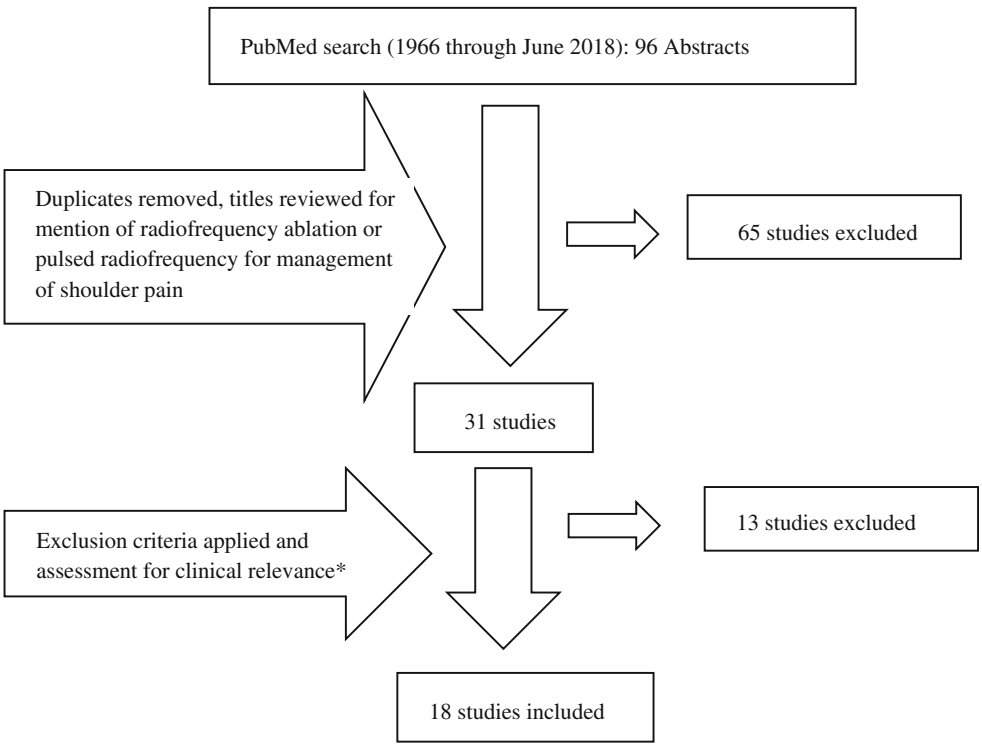

Fig. 1 Diagram illustrating our literature search methodology

Table 1 Characteristics of studies included in our systematic review

Author	Clinical diagnosis	Study size	Study design	Ablation technique	Ablated nerve	Duration of pain relief	Secondary outcome	Side effects	Conclusion
Chang et al. 2015	Malignancy associated recalcitrant shoulder pain	6 patients	Case series	Continuous 80 °C for 75 s	Suprascapular nerve	Patients reported improved pain relief instantaneously.	Two patients reported greater than 30% improvement in their active shoulder range of motion	None	Shoulder pain was due to metastatic cancer in patients with malignancy for usually greater than 2 years. These patient on average survived 60 days after the block. The block was effective for this period of time.
Eyigor et al. 2010	Chronic shoulder pain	50 (25 in PRF and 25 in intra-articular steroid group)	RCT	Pulsed at 45 V, 200 ms, 42 °C for 4 min	Suprascapular nerve	Improved pain, ROM, and quality of life. Improvement lasted 12 weeks. VAS scores at night on average went from 6.5 to 4.6 at 1 week, 2.7 at 4 weeks, and 1.6 at 12 weeks. On exertion, VAS scores went from 6.3 to 4.3 at 1 week, 2.7 at 4 weeks, and 1.6 at 12 weeks.	Paracetamol consumption decreased.		PRF was compared with intra-articular corticosteroids. Both had similar effects; however, the corticosteroids had a faster improvement rate.
Gabrhelik et al. 2010	Chronic shoulder pain	28 patients	Retrospective analysis	Pulsed for 120 s at 40 V for 2 cycles	Suprascapular nerve	After 3 months, there was 50% pain reduction in > 70% of patients. Pain relief after 6 months was about 60%.	Improved range of motion. 60% of patients stopped using analgesics.	2 complications: brief hypotension after the procedure and small hematoma. 4 patients PRF therapy had no significant effect (1 of whom had a cervical pathology causing problems).	2 groups of patients were treated with PRF therapy. One group had PRF and local anesthetics, while another had PRF with local anesthetics and steroids. The steroids made no difference in pain relief.
Gofeld et al. 2013	Chronic shoulder pain	22 (10 lidocaine/-placebo and 12 PRF)	RCT	Pulsed at 42 °C for 120 s	Suprascapular nerve	PRF group was on average more satisfied than the lidocaine group at 1 and 3 months. The average Likert-based score was 5.7 in the PRF group and 3.7 in the lidocaine group at 1 month, while at 3 months it was 6.0 in the PRF group and 3.9 in the lidocaine group. At 6 months there was no statistical difference.	SPADI scores improved. 56.2 preprocedure, 41.2 1 month after, 35.2 3 months after, and 36.4 6 months after.	A more significant dropout rate was seen in the placebo arm of the trial.	Significant trends in the reduction of pain are seen in the PRF group, but not in the lidocaine group. Further, patient satisfaction was sustained for at least 3 months post-procedure in the lidocaine group.
Huang et al. 2010	Frozen shoulder	2 patients	Case series	Pulsed at 42 °C for 120 s for 2 cycles	Suprascapular nerve	In the first patient, pain decreased from 8/10 to 3/10 and lasted 5 months. In the second patient, pain decreased from 9/10 to 3/10 and lasted 6 months.			Ultrasound guidance should be used to assist with PRF placement.
Jang. et. al. 2013	Chronic shoulder pain	11 patients	Case series	Pulsed at 42 °C, for 240 pulses at 50 V	Suprascapular nerve	VAS score of the 11 patients before PRF was 6.4, and the score at 6 months was 1 and at 9 months was 1.5.	Significant improved oxford shoulder score. The mean OSS before PRF was 22.7, at 6 months was 41.5, and at 9 months was 41.		PRF improves chronic shoulder pain and shoulder function.

Table 1 (continued)

Author	Clinical diagnosis	Study size	Study design	Ablation technique	Ablated nerve	Duration of pain relief	Secondary outcome	Side effects	Conclusion
Kane et al. 2008	Cuff tear arthropathy	12 patients	Case series	Pulsed for 120 s 2 or 3 times for a total treatment time of 6 to 8 min	Suprascapular nerve	Ten patients showed improvement in VAS score for 3 months. Pain increased between 3 and 6 months. VAS score is 6.2 before, 4.2 at 3 months, and 3.9 at 6 months.			PRF is a useful therapy for patients with painful, end-stage rotator cuff tear arthropathy in patients who are unfit for surgery.
Kim et al. 2012	Calcific tendonitis	1 patient	Case report	Pulsed lesioning at 42 °C for 120 s 3 times	Axillary and suprascapular nerve	VAS score was 5–6/10 before the procedure. 1 month after pain was 3/10 and then it was 1/10 at 2 months. Pain relief lasted 6 months.			The combination of suprascapular and axillary nerve blocks lead to good pain control in patients with severe intractable shoulder pain.
Korkmaz et al. 2011	Chronic shoulder pain	40 (20 in PRF and 20 in TENs arm)	RCT	Pulsed at 42 °C, 45 V, and 200 ms for a total of 4 min.	Suprascapular nerve	VAS scores at night before treatment: 6.3, down to 4.4 at 1 week, 2.7 at 4 weeks, 1.8 at 12 weeks. At rest VAS scores were 3.8 pretreatment, 2.4 at 1 week, 1.3 at 4 weeks, and 0.8 at 12 weeks. During movement VAS scores went from 7 pretreatment, to 5.2 at 1 week to 2.9 at 4 weeks, and 2.3 at 12 weeks.	Reduced consumption of the paracetamol.	None	When TENs was compared to PRF, there was no difference in treatment of shoulder pain. They lead to similar outcomes in terms of pain, range of motion, and quality of life in terms of treatment for painful shoulders.
Lipov et al. 2013	Chronic shoulder pain	3 patients	Case series	Pulsed at 42 °C, 500 KHz applied at 2 bursts/s, with each burst lasting 20 ms	Intra-articular and intrabursal	VAS scores in patient 1: 8/10 before and 3/10 at 2 and 4 weeks VAS scores in patient 2: preprocedure 9/10, after 3 PRF treatments VAS scores ranged from 3 to 5/10 up to 1 year out VAS scores in patient 3: 9/10 before and then 1/10 at 1 day out and up to 2 years out	Improved range of motion.		PRF can be beneficial in resolving shoulder pain.
Luleci et al. 2011	Chronic shoulder pain	57 patients	Prospective study	Pulsed at 42 °C, 2 Hz at 40 V w/20 ms active and 480 ms silent	Suprascapular nerve	PRF resulted in pain relief in 74% of patients at 3 months. 10 patients showed partial improvement. 45 patients showed improvement at 6 months.		5 patients showed no improvement; 2 underwent surgery for newly diagnosed cervical disc hernia. No side effects.	PRF is beneficial in patients with medical treatment resistant shoulder pain.
Okmen et. al	Chronic shoulder pain	59 (29 in the photomodulation group and 30 in the PRF group)	RCT	Pulsed at 42 °C for 240 s	Suprascapular nerve	Both groups had a decline in pain scores. VAS scores in the PRF group went from 6.4 to 2 immediately post treatment, to 1.5 at 1 month, 2.1 at 3 months, and 2 at	Both groups resulted in improved functional status in the patient. SPADI scores in the PRF group went from 37.5 pretreatment to 11.5 post treatment, to 10		Both photomodulation and PRF are equally effective in treating chronic treatment resistant shoulder pain.

Table 1 (continued)

Author	Clinical diagnosis	Study size	Study design	Ablation technique	Ablated nerve	Duration of pain relief	Secondary outcome	Side effects	Conclusion
						12 months.	1 month after, 13.5 at 3 months after, and 12 6 months out		
Ozyuvaci et al. 2011	Chronic shoulder pain	3 patients	Case series	–	Intra-articular PRF of glenohum-oral joint	Patient 1: 6/10 preprocedure and 3/10 at 3 weeks after Patient 2: 7/10 preprocedure and 4/10 at 3 weeks. Patient 3: 8/10 preprocedure and 6/10 post procedure.			Intra-rticular PRF is not sufficient to manage chronic shoulder pain.
Shah et al. 2003	Chronic shoulder pain	1 patients	Case report	Pulsed at 42 °C for 3 cycles of 120 s (2 Hz and pulse width of 20 ms)	Suprascapular nerve	Preprocedure pain was 7/10 and post-procedure pain was 2–3/10. Relief last 12–18 weeks.	Improved shoulder ROM for 15 weeks.		In patients with shoulder pain that aren't candidates for arthroplasty, multiple treatments of PRF can be used.
Simopoulos et al. 2012	Chronic shoulder pain	9 patients	Case series	Continuous percutane-ous radiofre-quency lesion at 80 °C for 60 s	Suprascapular nerve	Pain scores were 7.2/10 before procedure and 3/10 5–7 weeks post procedure. Pain relief lasted from 3 to 18 months. All patients underwent an additional treatment.	Modest improvement in ROM of the shoulder.	None	CRF can lead to improved shoulder pain. The selected patients in this study had improved pain relief with local anesthetic block.
Sluijter et al. 2008	Chronic shoulder pain	1 patients	Case report	Pulsed at 42 °C for 14 min at 2 Hz w/pulse width of 10 ms and 55 V	Subacromial PRF	Preprocedure pain at 7–8/10 and post procedure pain at 4/10.	Stopped PO pain medication		PRF can be used an alternative for intra-articular steroid injections to provide a longer duration of pain relief.
Taverner et al. 2014	Chronic shoulder pain	51 (40 patients had a rotator cuff, 18 acromioclavicul-ar or glenohumoral osteoarthritis, 11 tendinopathy, 7 bursitis, and 2 frozen shoulders) 25 in active tx and 26 in sham	RCT	Pulsed at 80 V using 2 min, 10 ms, 5 pulses per second bipolar treatments	6 standardized sites around the painful shoulder	Preprocedure: pain at night: 5.6; pain at rest: 2.2; pain with activity 6.9. At 4 weeks, rest pain went down by 0.5 and active pain went down by 2 and night pain down by 2 At 12 weeks, active pain down by 1.8; rest pain down by 0.3 and active pain down by 1.9. The NNT to decline shoulder surgery after active treatment at 12 weeks was 4.4.	Only small decline in number of analgesic tablets		PRF may create a weak electronic field that results in long-term depression of synaptic transmission. It may also reduce the production of inflammatory cytokines IL-1, TNF-a, and IL-6, which may reduce C reactive protein. As a result, pain is reduced.
Wu et al. 2014	Adhesive capsulitis	42 (21 in each arm) patients	RCT	Pulsed lesioning at 42 °C for 180 s (2 Hz, 30 ms pulse width)	Suprascapular nerve	Improved pain control. Baseline VAS was 6.5; at 1-week follow-up it was 3.9; 4-week follow-up, it was 3.9; 8-week follow-up, it was 2.2 and at	Decreased disability index and improved range of motion. No other treatments were administered other than physical therapy. SPADI scores improved from a	18 patients dropped out of the study. 4 patients reported mild tingling or pain at puncture site that resolved within 1 h.	PRF combined with physical therapy leads to faster onset, longer duration, and reduced disability compared with just physical therapy.

Table 1 (continued)

Author	Clinical diagnosis	Study size	Study design	Ablation technique	Ablated nerve	Duration of pain relief	Secondary outcome	Side effects	Conclusion
						12-week follow-up, it was 1.7.	baseline of 55.6 to 37.3 1 week after, 26.8 4 weeks after, 20.5 8 weeks after and 15.6 at 12 weeks after.		

Assessment of Study Quality

Two authors (RG and VO) used the Cochrane Risk of Bias, which was used to measure the methodological quality of the randomized controlled trials. The Cochrane Risk of Bias has seven items included to assess the internal validity of each of the randomized controlled trials. Each of the studies is scored via allocation of "+," "−," or "?" to each criterion that is met or unmet. Six randomized control trials were reviewed, and the data was extracted and included in the table (Table 2).

Results

Search Result

Our final search methodology resulted in 18 studies that investigated the use of RFA or PRF on the shoulder. We identified 96 articles for initial review. Once the inclusion criteria were applied, there were 31 articles remaining for review. And then, the exclusion criteria were applied yielding the 18 studies included in this article. These 18 studies included 6 randomized control trials, 1 prospective study, 1 retrospective study, and 10 case reports or series. The studies were published from 2003 to 2017 with a follow-up period of up to 2 years.

Outcomes for Continuous or Pulsed Radiofrequency Treatments

Sixteen of the 18 studies performed PRF treatments at 42 °C, while two studies performed continuous ablative techniques at 80 °C. Temperatures were noted only when available. The

Table 2 Cochrane risk of bias assessment of randomized controlled trials investigating the role radiofrequency ablation in patients with shoulder pain

Title	1	2	3	4	5	6	7	Total
Eyigor et al. 2010	1	0	0	0	0	1	1	3
Gofeld et al. 2013	1	1	1	1	1	1	1	7
Korkmaz et al. 2011	1	0	0	0	0	1	1	3
Okmen et al. 2017	1	0	0	0	0	1	1	3
Taverner et al. 2014	1	1	1	1	1	1	1	7
Wu et al. 2014	1	0	0	0	0	1	1	3

1. Random sequence generation (selection bias)
2. Allocation concealment (selection bias)
3. Blinding of participants and personnel (performance bias)
4. Blinding of outcome assessment (detection bias)
5. No incomplete outcome data (attrition bias)
6. No selective reporting (reporting bias)
7. No other bias

treatments varied from as short as 75 s to 8 min. The majority of studies targeted the SSN, while a couple of studies targeted multiple sites. The primary diagnosis of those involved in the study was chronic shoulder pain. There were also articles that discussed the primary diagnosis of adhesive capsulitis, malignancy-associated shoulder pain, frozen shoulder, cuff tear arthropathy, and calcific tendonitis.

Outcome

Pain outcomes were reported as VAS or NRS by most of the publications in the review. Simultaneously, functional outcome data (shoulder pain, Oxford shoulder score, and disability index or range of motion) was collected, but often limitedly reported. Further, in a single study, patient satisfaction scores were reported. In the randomized studies, dropout rates may have been significant in the placebo arms. In all but one study, which highlighted an intra-articular application of PRF, the pain scores improved using PRF or continuous ablative techniques.

Discussion

Our analysis reviewed 18 studies that investigated the use of RFA and PRF therapy of the shoulder. Of the identified 18 studies in our analysis, including 6 randomized control trials, 1 prospective study, and 1 retrospective study, 7 were case series and 3 case reports.

In a sample of 50 patients, Eyigor et al. evaluated the effect of intra-articular injection of corticosteroid in comparison with PRF of the SSN to treat chronic shoulder pain [17••]. Outcome variables included pain using a VAS, range of motion, Shoulder Pain and Disability Index (SPADI), the Short Form-36, Beck Depression Scale questionnaires, and paracetamol consumption. In comparison with pretreatment, both groups demonstrated significant improvements in VAS, active and passive ROM, SPADI subscores, and paracetamol consumption. Eyigor et al. found a statistically significant difference in favor of intra-articular injections, compared with PRF in both passive and active ROM measurements, SPADI pain and total subscores at weeks 1, 4, and 12, and paracetamol consumption. In whole, PRF of the SSN offered improved long-term relief though intra-articular corticosteroid injection, which appeared to be more effective in the first weeks of therapy.

Gabrhelik et al. retrospectively evaluated the effect of PRF to the SSN in 28 patients with shoulder pain lasting longer than 1 month in duration, with follow-up at 6 months [14]. Their pain scores were evaluated before the procedure, immediately after, and then at 1, 3, and 6 months. One group received local anesthetic solution, while the other group received a combination of local anesthetic, steroid, and PRF to the SSN. Outcome variables included pain duration, pharmacological treatment prior to block, and preprocedural VAS at night, at rest, and during active shoulder movements. Postprocedural VAS at 24 h, 3 months, 6 months, at rest, and during active shoulder movements, patient satisfaction, complication rate, and changes in analgesic medication were also measured. Mean VAS was similar in both groups at rest and with shoulder movement; however, significant improvement in pain was reported immediately following treatment in both groups. At 3 months, both groups continued to report at least 50% pain reduction in pain. At 6 months, however, while both groups continued to report pain reduction, the group which underwent PRF reported significantly better pain relief. Two minor complications were reported including transient postprocedural hypotension secondary to routine medication use and a small hematoma at the insertion site. This study suggests that pain relief from PRF appears to be long-lasting with minimal side effects.

Gofeld et al. evaluated the use of lidocaine injections alone or in combination with PRF for SSN blockade in the management of chronic shoulder pain [18]. This randomized active placebo control double-blind trial investigated 22 participants that were followed for a period of 6 months. This study had some difficulty with recruitment as well as high dropout rates. Hence, the study had to be redesigned due to a resultant small sample size. Subjects who received PRF reported an improvement in the numeric rating scale, SPADI scores (56.2 at preprocedure, 41.2 at 1 month after, 35.2 at 3 months after, and 36.4 at 6 months after), and Constant-Murley score, which was not observed in the lidocaine group. In addition, the PRF group reported more satisfaction at 1- and 3-month follow-ups ($P = 0.041$ and $P = 0.035$, respectively). The average Likert-based score was 5.7 in the PRF group and 3.7 in the lidocaine group at 1 month. At 3 months, it was 6.0 in the PRF group and 3.9 in the lidocaine group. This study suggests that PRF may be beneficial in the management of chronic shoulder pain.

Orkmen et al. and Korkmaz et al. reported similar findings with no significant difference in efficacy between photobiomodulation therapy (PBMT) and SSN-PRF and between PRF and TENS [19, 20••]. Orkmen et al. evaluated the efficacy of PBMT and SSN-PRF therapy in a prospective, randomized controlled, single-blind study of 59 patients with chronic shoulder pain. Both groups also received exercise therapy for 14 sessions over 2 weeks. Data was collected for pretreatment (PRT), post-treatment (PST), and PST follow-up at months 1, 3, and 6. Both groups reported a decline in pain scores. VAS scores in the PRF group went from 6.4 to 2 immediately post-treatment, 1.5 at 1 month, 2.1 at 3 months, and 2 at 12 months. Both groups also reported improved functional status with SPADI scores in the PRF group decreasing from 37.5 in pretreatment to 11.5 in post treatment. Subsequent SPADI scores in the PRF group were 10 at

1 month, 13.5 at 3 months, and 12 at 6 months. No statistically significant difference was found between both study groups. Outcome measures of PRT, PST, and PST at 1, 3, and 6 months, VAS, SPADI, and NHP values were significantly lower in both groups ($P < 0.001$); however, there was no statistically significant difference between the two groups at any time point [20••]. This study suggests that in patients with chronic shoulder pain, PBMT and SSN-PRF therapies were both effective in addition to exercise therapy.

Korkmaz et al. in a randomized controlled trial evaluated the efficacy of PRF compared with conventional transcutaneous electrical nerve stimulation treatment, applied to the SSN, in patients with shoulder pain [19]. Outcome measures included visual analogue scale for pain and range of motion. The Shoulder Pain and Disability Index was used for disability, and the Short Form-36 was used to evaluate quality of life. These outcomes were recorded prior to the intervention and at 1, 4, and 12 weeks after. No statistically significant difference was found between two groups in terms of the outcome measures, the consumption of paracetamol, and the physician–patient satisfaction rate. A statistically significant difference was observed in favor of PRF observed only in week 1 in the Shoulder Pain and Disability Index total scores. Statistically significant improvements were also reported in both arms when comparing outcome measures in weeks 1, 4, and 12 to the pretreatment period. The study, however, found no difference in effect between transcutaneous electrical nerve stimulation and PRF treatment for management of shoulder pain.

In another prospective study by Luleci et al., patient satisfaction, efficacy, and safety of the PRF technique applied to the SSN for the treatment of refractory shoulder pain was evaluated in 57 patients [21]. Patients were evaluated before the procedure and at 3 and 6 months after the procedure. Outcome measures include pain relief measured on an 11-point verbal numerical rating scale (VNRS) and modified MacNab score. Significant pain relief was defined as greater than a 50% decrease in VNRS, while 20 to 49% were interpreted as partial pain reduction. In this study, 73.7% patients reported significant relief, while 17.5% showed partial improvement in pain scores. A total of 8.7% reported no changes in pain scores. This study showed that PRF application to the SSN for 480 s provided significant relief of chronic shoulder pain.

Taverner et al. evaluated the effect of transcutaneous PRF treatment (TCPRFT) on 51 patients in a randomized double-blinded study [22]. Patients were assessed at baseline (T0), 4 weeks (T4), and 12 weeks (T12). The primary outcome measure was pain intensity at night, rest, and during activity of the treated shoulder. Secondary outcomes were self-reported brief pain inventory (BPI), pain self-efficacy, and Oxford shoulder score questionnaire scores, arm elevation, arm internal rotation, and global perceived effect. They recorded pain using a 0 to 100 VAS slide rule. A 20/100 reduction in VAS pain intensity or 30% reduction in pain intensity score was reported as a clinically relevant change. Patients treated with PRF reported statistically significant reductions in pain at night and with activity at 4 and 12 weeks follow-up [22]. Lower BPI and function scores were also reported at 4 and 12 weeks. Additional improvement in the following pain areas and their respective time-points were also reported: improved pain self-efficacy (4 weeks), Oxford shoulder scores (12 weeks), and internal rotation (12 weeks). This study suggests that transcutaneous PRF treatment may help with the mitigation of chronic shoulder pain.

In their randomized control trial, Wu et al. in 2014 evaluated the effect of physical therapy alone and physical therapy with PRF lesioning of the SSN in 60 patients with adhesive capsulitis (AC) [23]. Outcome measures were VAS, shoulder pain with disability index, and passive range of motion (PROM). These were recorded at 1, 4, 8, and 12 weeks after treatment. Patients in the intervention group had a notably shorter time to onset of significant pain relief (6.1 ± 3.4 vs 28.1 ± 9.2 days; $P < 0.001$) and noticeable reduction of VAS score at week 1 (40% vs 4.7%) than the control group ($P < 0.001$) [23]. Shoulder pain, disability index scores, and PROM also showed statistically significant improvement. This study suggested the use of PRF lesioning of the SSN combined with physical therapy, which provided better, faster, and sustained relief from pain lasting up to 12 weeks in patients suffering chronic pain from AC.

Despite the positive finding identified in this review article, this systematic review has a few limitations. While PRF was found to be predominantly beneficial, the study structures and designs of the intervention arms included a combination of PRF with other treatment modalities, including steroids and physical therapy. This use of adjunct therapies makes it difficult to critically evaluate the efficacy of PRF in patients with shoulder pain. Additionally, different techniques of ablation as well as varying study lengths and follow-up periods were also utilized. This confounds the actual duration of pain relief provided by PRF in patients with shoulder pain. Furthermore, outcomes were overarchingly in favor of PRF or similarly in favor of PRF. The inclusion and exclusion criteria also varied among the different RTCs evaluated in this review. Almost half of studies analyzed that 8 of 18 were either RTCs, prospective, and retrospective studies with slightly greater than half being case series or studies.

Conclusion

RFA is a promising therapy for the management of chronic shoulder pain. All of the prospective and retrospective studies reviewed suggested a potential benefit of RFA in the treatment of patients with shoulder pain. However, this is limited by varying methodologies and small sample sizes. Further

research with standardized protocol, larger sample sizes, and with longer follow-up is needed to better assess the efficacy and safety of RFA for patients with shoulder pain.

Compliance with Ethical Standards

Conflict of Interest Vwaire Orhurhu, Olayinka Akinola, Ravi Grandhi, and Ivan Urits declare that they have no conflict of interest. Dr. Abd-Elsayed is a consultant for Medtronic, Stimwave, Halyard, SpineLoop, and Sollis.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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