Narrative Review

The Utilization of Radiofrequency Techniques for Upper Extremity Pain Management

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Background: In the 1990s, radiofrequency ablation emerged as a novel therapeutic approach tool for pain alleviation that did not result in neurological harm. Radiofrequency techniques are emerging methods as a possible option for upper extremity pain management. Furthermore, joint pain can result from multiple etiologies, and the management can differ based on what joint is affected. With the various management methods available to treat joint pain, radiofrequency ablation could be an effective, minimally invasive, promising intervention.

Objectives: This study aimed to review the current and historical uses of radiofrequency in upper extremity pain compared to other management methods and to address the utilization of radiofrequency in upper extremity pain management.

Study Design: This is a narrative review of relevant studies on using radiofrequency techniques in upper extremity pain management.

Methods: On June 26, 2022, Medline/PubMed, Google Scholar, ERIC, and the Cochrane Database of Systematic Reviews were searched for relevant literature documenting the use of radiofrequency techniques in treating upper extremity pain. The terms "radiofrequency," "pain," "upper extremity," "shoulder," "elbow," and "wrist" were used, resulting in 61 studies fitting the inclusion criteria. A narrative review was then undertaken.

Results: Radiofrequency ablation and its techniques are among the contemporary medical procedures that could be cost-effective solutions for patients suffering from chronic and postoperative pain. Its utilization for shoulder-related pain has been frequently studied, as it showed significant improvement with a high satisfaction rate as a solo procedure. When compared to intraarticular corticosteroid injections or local anesthetics, it was found to be more effective than local anesthetics. Although it did not appear superior to intraarticular corticosteroid injections, it had the advantage of infrequent repeat treatment. By comparison, studies involving the elbow and wrist showed promising results but were not as thorough as studies on the shoulder. Therefore, considering the possible side effects and complications, caution is warranted.

Limitations: The paucity of articles available on its application to the elbow and wrist joints. More articles are necessary for the generalizability of the results.

Conclusion: Radiofrequency techniques are a promising, minimally invasive procedure for controlling upper extremity pain. More studies on the topic, especially on elbow and wrist pain, are warranted for the generalizability of the results.

Key words: Radiofrequency, pain management, upper extremity, shoulder, elbow, wrist, corticosteroid injection, local anesthetics

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Radiofrequency ablation (RFA), also known as neurotomy or rhizotomy, was first described by Kirschner in 1931 (1). It works by emitting thermal energy and is typically applied near or on the peripheral nerve origins along the levels of the spinal cord for multiple purposes (2). It further evolved, and

in the 1950s the first commercial RFA generator was produced (3). In the 1990s, RFA emerged as a novel therapeutic method for pain relief that did not cause neural injury (4).

Radiofrequency techniques can be classified into 3 main categories: ablative (conventional), cooled, and pulsed. Ablative radiofrequency (aRF) necessitates temperatures of 70°C – 80°C and causes neuronal destruction, while cooled radio frequency is used at a temperature of 60°C. Despite the reasonable cost and good pain relief offered by these, conventional might have a reduced pain relief duration due to the parallel placement of the probe to the nerve. On the other hand, cooled RF overcomes multiple downsides that occur in the conventional, such as the ability to direct continuous ionic heating to generate larger thermal and spherical lesions that, in turn, allow better probe placement and provide a larger distal projection. Pulsed radiofrequency (pRF) is often used at temperatures of 40°C – 45°C; while it doesn't cause neural injury, it works by preventing neuronal function loss while producing supposed neuromodulatory effects that lead to analgesia (5–7). Aside from pain relief, RFA has multiple uses: cellulite reduction, acne scar revision, and the treatment of hypertrophic scars (8).

Orthopedic surgeons encounter various traumatic and overuse injuries in musculoskeletal and neurologic systems (9). Shoulder pain is one of the most prevalent reasons for patients seeking medical attention (10). It has been estimated that shoulder pain affects up to 30% of the US population and has a significant socioeconomic influence on everyday lives (11–13). Moreover, the elbow joint is a site of various diseases, given its complexity (9). Elbow pain can result from multiple causes, including epicondylitis, which is estimated to range between 1% – 3% in the general population (14–16). Wrist pain can result from traumatic and nontraumatic events (17). It is estimated that among the general population and nonmanual labor employees, the incidence of short-term (few days) and medium-term (a couple of weeks) wrist pain is 6% and 4.2%, respectively (18).

Highlighting the effect of upper extremity pain and the variety of management methods is crucial. Due to the literature's gap in addressing the utilization of RFA in pain management, we aimed to review the current and previous uses of RFA in upper extremity pain and compare it to other pain management methods.

Methods

Source of Information, Search Terms, and Delimiting

In this study, Medline/PubMed, Google Scholar, ERIC, and the Cochrane Database of Systematic Reviews were searched on June 26, 2022. References to relevant reviews, along with database searches, were also explored. The following MeSH terms were searched: "radiofrequency," "pain," "upper extremity," "shoulder," "elbow," and "wrist."

Inclusion and Exclusion Criteria

The inclusion criteria were adults with shoulder, elbow, or wrist pain who received any form of radiofrequency therapy for pain management. Interventional studies, reviews, original articles, prospective and retrospective studies, case series, and case reports conducted from 1990 to the present were included. Studies performed on cadavers or conducted on animals were excluded. Papers in which the authors utilized radiofrequency techniques for pain management in nonupper extremity parts and for purposes other than pain management, such as managing tumors (e.g., osteoid osteoma), referred pain, and neuropathic syndromes, were also excluded. Moreover, letters to editors and any article with a language barrier, such as non-English articles and nonopen access articles, were excluded after corresponding with its primary authors for a full access version.

Data Extraction

The final evaluation extracted from the previously described papers was performed with a standardized extraction form. The extracted information included the primary author's last name, the type of study, the year of publication, the location (e.g., city or country), the sample size, and a significant conclusion. It also included the involved joint, specifically the shoulder, elbow, or wrist. When available, the pain scale scoring systems used were identified.

Results

A total of 129 studies were found. After removing the duplicated studies, the number was reduced to 99. All the articles were documented in one spreadsheet. The authors conducted a thorough title and abstract scanning to determine their eligibility for inclusion. The studies that found pain management in the upper extremity irrelevant were directly excluded, as were those articles falling under our exclusion criteria, leav-

ing a final number of 59 studies eligible for inclusion (Fig. 1).

Of the final included studies, 51 discussed RFA techniques for the shoulder joint, 2 for the elbow, and 3 for the wrist joint. Overall, the shoulder, elbow, and wrist studies involved 18 randomized controlled trials, 3 clinical studies, 3 prospective studies, 11 review articles, 6 case reports, 8 case series, and one pilot study.

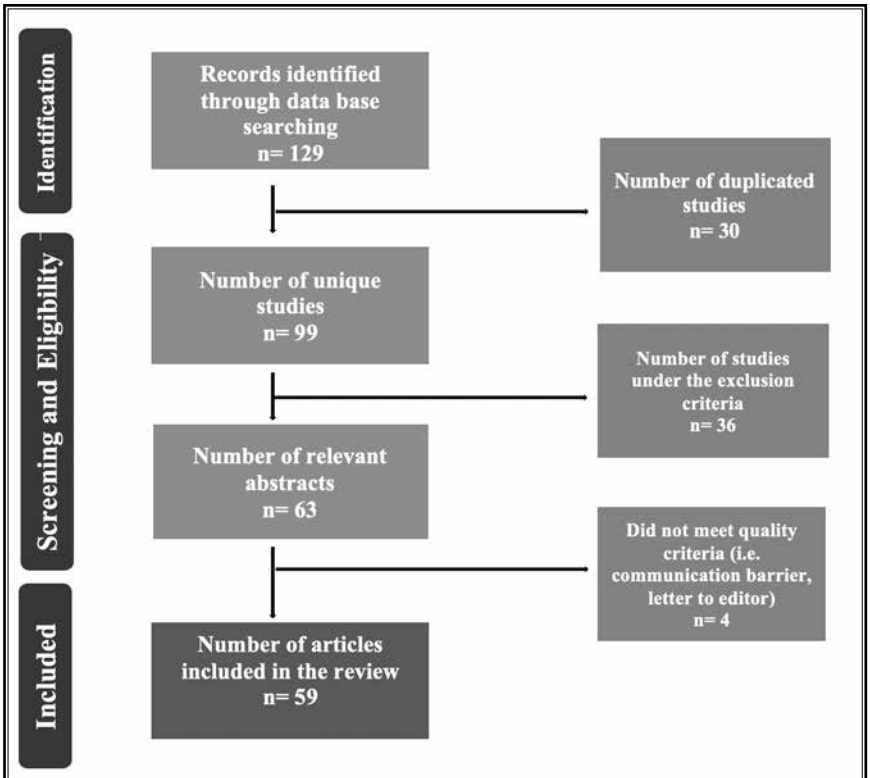

Fig. 1. *Flowchart summarizing the identification and selection of articles.*

Discussion

RFA is a current medical procedure that could be a cost-effective solution for patients suffering from chronic and postoperative pain (19,20). It is a minimally invasive solution to many orthopedic issues, such as those of the upper extremity, which might involve trauma or chronic wearing down of the joints (21). Radiofrequency therapy causes desirable effects, mainly by lesioning the nerve by directing thermal waves to it at a specific point, inhibiting pain impulses from distal areas to the nerve without impairing motor functions (22). RFA therapy began predominantly as an intervention for facial pain. However, due to the evolution of medicine, it has become an option for pain in other areas of the body, such as pathologies involving the spine and the pelvis (23). RFA prevents patients' nerves from transmitting pain signals from any lesion originating in an area supplied by the nerve treated with RFA.

Currently, RFA therapy mainly consists of conventional, water-cooled RFA, and pulsed RFA (22). Their difference mainly lies in the delivery mechanism of the heat waves lesioning the nerve. In conventional RFA, thermal energy waves are continuously emitted at the nerve point, which heats the tissue to 45°C - 50°C. This procedure is also known as the "lethal temperature range" (24). In pulsed RFA, the heat waves are emitted at a frequency of 1 Hz – 8 Hz, unlike conventional RFA, which is continuous. Interestingly, it is believed that pulsed RFA causes minor vacuolizations and cytoskeleton changes with no clinical manifestation of neural destruction (24).

Radiofrequency techniques are emerging as a possible option for upper extremity pain management. Thus, exploring supporting or opposing evidence for their use is significant to their application. RFA shows significant potential to evolve even more, given recent medical advancements (25).

RFA for Shoulder Pain

The shoulder joint, commonly referred to as a ball-and-socket joint, is one of the human body's most dynamic, complicated joints. A network of tendons and ligaments stabilizes it (26,27). RFA is an excellent alternative treatment for those who cannot undergo surgical intervention, whether they are unsuitable candidates or there is simply a long waiting time (28). Consequently, RFA aligns with the importance of shifting unnecessary surgeries into safer, minimally invasive interventions, such as RFA (29). This procedure is usually conducted under ultrasound guidance, among other guiding techniques (30,31). Yet both showed positive outcomes when the ultrasound-guided technique was compared with the fluoroscopy-guided technique to identify the suprascapular nerve (SSN) and the axillary

nerve (32) (Fig. 2). In a case report, ultrasound and fluoroscopy were combined to identify the structures to introduce a novel RFA technique to ablate the lateral pectoral nerve. Eventually, the procedure resulted in substantial continued relief of anterior shoulder pain over 3 months (33).

RFA's application for pain management can range from joint pain, such as that caused by shoulder pathologies, which may involve other upper limb pathologies (34). The utilization of RFA in the shoulder to alleviate pain has been frequently reviewed (Table 1). Of those reviews, 2 systematic reviews investigated the role of RFA in managing shoulder pain. They both concluded that RFA significantly improves shoulder pain and is relatively safe (35,36). Two review articles done by Eckmann et al (37), and Tinnirello et al (21) supported the previously mentioned benefits.

Conversely, in their systematic review, Pushparaj et al (38) indicated that there is still a lack of evidence of an analgesic effect despite the potential pain reduction. In line with that, Huygen et al's review (39) recommended considering RFA in cases of failed conservative management. Similarly, Samaan et al's review (40) identified RFA as an alternative approach when shoulder pain is refractory using other approaches. In addition, 2 trials, one in Australia (41) and the other in China (42), compared using the RFA technique on patients suffering from chronic shoulder pain in comparison with a sham group. Both studies showed promising outcomes, indicating that RFA can provide effective pain management for up to 3 months (41,42).

In Portugal, 2 trials were carried out by Ergonenc et al (43), and Pinto et al (44). These trials affirmed that RFA provides pain control for up to 6 months and maintains good motor function. Moreover, when RFA was applied to patients experiencing pain following reverse shoulder prosthesis surgery, and the results compared to those of a placebo group, the use of painkillers and pain steadily declined in the intervention group (45). Furthermore, 2 interventional studies were carried out by Luleci et al (46), and Baysal et al (47) to assess the satisfaction and efficacy of RF in managing chronic shoulder pain. These studies reported significant improvement and a high satisfaction rate, which was also seen in 2 studies carried out in the Netherlands and Taiwan (48,49).

Moreover, in a patient with shoulder pain with a history of shoulder acromioplasty, the patient achieved 90% pain relief after the 4th session of RFA (50). Furthermore, following RFA, a patient who had lasting shoulder and arm pain that turned out to be calcific tendonitis, had the shoulder pain subside, and the patient no longer needed pain management (51).

The duration of pain relief varied among studies,

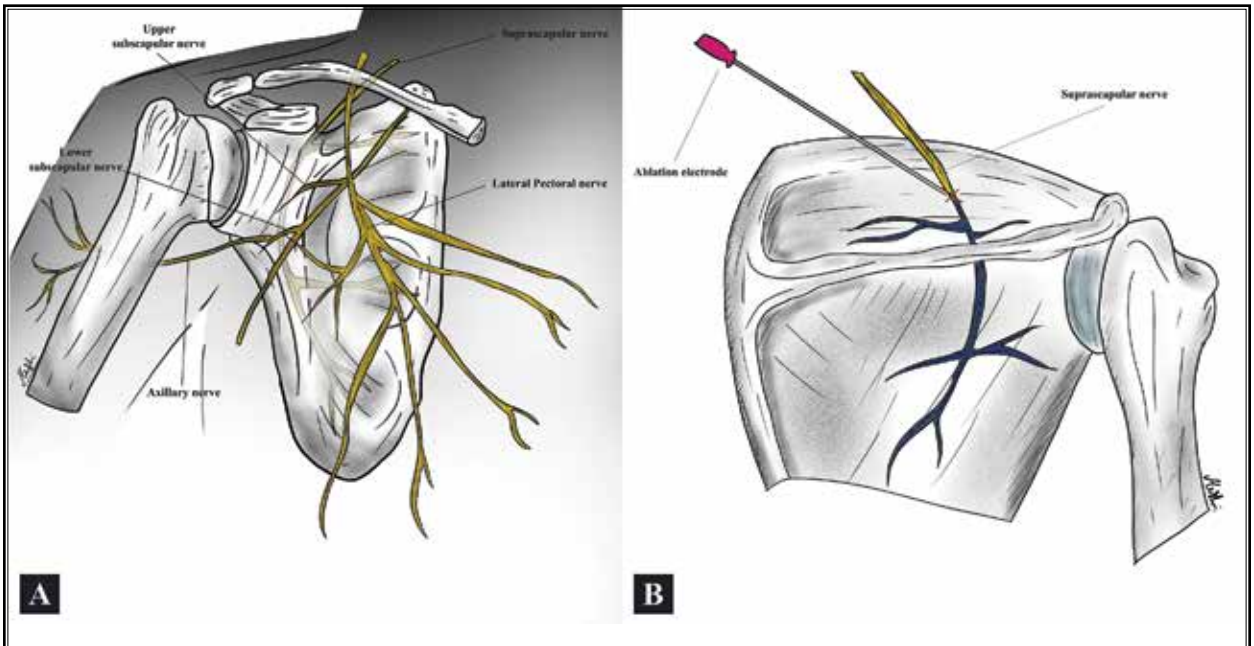

Fig. 2. *RFA of the SSC nerve at the shoulder.*

Table 1. *Radiofrequency Application for Shoulder Pain*

Intervention	Reference	Study design	Results/conclusion
Radiofrequency ablation	Kallas et al. (28), 2022	Review article	Cooled radiofrequency is a promising tool to consider for patients with shoulder osteoarthritis after conservative management and before surgery.
	Sag et al. (29), 2022	Review article	Following the paradigm of using minimal intervention procedures instead of open surgeries, CT guidance provides safe, fast, effective targeting of the nerves.
	Esparza-Miñana et al. (30), 2019, Spain	Interventional study	The US-guided technique is effective and can safely deliver pulsed radiofrequency to the suprascapular and axillary nerves to treat shoulder pain.
	Wu et al. (32), 2014, China	Randomized controlled trial	Pulsed radiofrequency lesioning of the SSN using US guidance in adhesive capsulitis provides fast, effective pain relief.
	Eckmann et al. (34), 2020	Review article	Ablation procedures of the shoulder should be performed with attention to anatomy. Moreover, SSN, AN, and lateral pectoral nerve ablation have been reported, and subscapular nerve ablation is still possible.
	Jump et al. (35), 2021	Meta-analysis	SSN ablation and nerve blockage are associated with significant improvements in shoulder pain and the range of motion in patients with frozen shoulders.
	Orhurhu et al. (36), 2019	Systematic review	Shoulder RFA provides safe, effective management of chronic shoulder pain.
	Eckmann et al. (37), 2021	Review article	RFA of the shoulder's articular branch is a safe, effective treatment for chronic shoulder pain.
	Tinnirello et al. (21), 2022	Review article	RFA is a effective, efficient treatment for chronic and postoperative pain in major joints, including the shoulder.
	Pushparaj et al. (38), 2021	Meta-analysis	RFA treatments target the sensory innervation of shoulder joints affected by degenerative conditions and can potentially reduce pain.
	Huygen et al (39), 2010	Review article	When conservative management fails for treating frozen shoulder, local anesthetic and small doses of opioids or a pRF treatment of the nervus suprascapularis can be considered.
	Samaan et al. (40), 2021	Review article	Radiofrequency ablation may serve as an alternative treatment plan for refractory shoulder pain from physical therapy, pharmacotherapy, and corticosteroid injections.
	Taverner et al. (41), 2014, Australia	Randomized controlled trial	Transcutaneous pRF may help some people with shoulder pain. Its ease of use may allow this to be an early option in the treatment course.
	Yan et al. (42), 2019, China	Randomized controlled trial	Ultrasound-guided pRF shows promising results for patients with shoulder pain due to a frozen shoulder after 12 weeks of treatment.
	Ergonenc et al. (43), 2018, Portugal	Interventional study	US-guided pRF of the suprascapular nerve in shoulder pain reduces pain intensity for at least six months, accompanied by high levels of patient satisfaction.
	Pinto et al. (44), 2021, Portugal	Prospective study	US-guided pRF of the suprascapular nerve reduces the intensity of pain for a duration of up to six months.
	Bianchi et al. (45), 2018, Italy	Prospective randomized trial	pRF therapy for managing postoperative pain due to reverse shoulder prosthesis is a safe, effective method.
	Luleci et al. (46), 2011, Turkey	Prospective study	The application of pRF to SSN for 480 sec results in significant improvement in patients' chronic shoulder pain.
	Baysal et al. (47), 2008, Turkey	Case series	Applying pRF to the SSN for eight minutes caused no complications. Patients also showed remarkable improvement in pain levels.
	Rohof et al. (48), 2002, Germany	Retrospective study	pRF might provide an alternative method in difficult cases without causing side effects and complications of standard neurolytic procedures.
	Liliang et al. (49), 2009, Taiwan	Interventional study	pRF to SSN is a potential treatment option for patients suffering from chronic shoulder pain. It provides long-lasting pain relief and decreases pain medication requirements.
	Kane et al. (60), 2008, UK	Randomized controlled trial	pRF may be a useful therapeutic adjunct in patients with painful, end-stage rotator cuff tear arthropathy who are medically unfit for surgery.
	Schianchi et al. (52), 2013, Switzerland	Retrospective study	pRF induced significant pain relief for a long duration in most patients with joint pain, with a higher success rate for small joints.
	Taverner et al. (53), 2013, Australia	Retrospective study	pRF therapy may provide clinically applicable pain relief and be another treatment modality for shoulder pain.

Table 1 (continued). *Radiofrequency Application for Shoulder Pain*

Intervention	Reference	Study design	Results/conclusion
Radiofrequency ablation	Sir et al. (54), 2019, Turkey	Retrospective study	US-guided SSN pRF achieves effective pain relief and functional improvement in patients with partial rotator cuff tears for at least six months.
	Huang et al. (31), 2010, Taiwan	Case report	pRF of the SSN successfully alleviated frozen shoulder patients' pain.
	Shah et al. (55), 2003, USA	Case report	pRF therapy of SSN for chronic shoulder pain provided pain relief and improved shoulder function without deterioration in muscle strength.
	Eckmann et al. (33), 2019, USA	Case report	RF therapy of the articular branch of the LPN may provide anterior shoulder analgesia without causing motor weakness.
	Simopoulos et al. (56), 2012, USA	Case series	Continuous RF lesioning of the SSN could be an effective treatment for chronic shoulder pain and the improvement of ROM of the shoulder.
	Tinnirello et al. (57), 2021, Italy	Retrospective study	Cooled RFA of the articular branches of the LPN, AN, and SSN successfully reduced pain and disability improvement.
	Lipov et al. (58), 2013, USA	Case series	pRF treatment improved pain and ROM.
	Ozyuvaci et al. (59), 2011, Turkey	Case series	Intra-articular RFA of the shoulder showed good improvement of the visual analog scales in all three cases.
	Perrizo et al. (50), 2012, USA	Case report	pRF ablation of the AN and SSN with fluoroscopic and ultrasonic guidance led to a 90% reduction by the fourth session.
	Kim et al. (51), 2012, Korea	Case report	pRF of AN and SSN led to shoulder pain gradually subsiding with a size reduction of the calcified nodule. The patient required no further pain management.
Radiofrequency ablation compared to steroid injections and/or local analgesia	Eyigor et al. (62), 2010, Turkey	Randomized controlled trial	IACI and pRF applied to the SSN effectively treated shoulder pain. IACI is potentially more effective than pRF.
	Kim et al. (63), 2021, Korea	Randomized controlled trial	IACI and pRF applied to the SSN were effective in the treatment of chronic hemiplegic shoulder pain. There was no statistically significant difference between the two treatments.
	Okmen et al. (64), 2017, Turkey	Randomized controlled trial	Corticosteroid and pRF both showed promising results in patients after a six-month follow-up, but statistical significance superiority to each other was not determined.
	Mermekli et al. (65), 2022, UK	Retrospective study	Ultrasound-guided RF of the SSN is a safe, effective procedure to treat patients complaining of chronic osteoarthritic shoulder pain.
	Sinha et al. (66), 2020, India	Randomized controlled trial	pRF of the SSN under US guidance is an effective treatment modality for managing chronic shoulder pain. The effects of a combination of pRF and a short-acting corticosteroid last up to 24 weeks.
	Gabrhelik et al. (67), 2010, Ireland	Retrospective study	pRF treatment of the SSN provides patients with long-lasting relief from chronic shoulder pain and can easily be repeated after symptom recurrence with decreased pharmacotherapy.
	Gofeld el al. (68), 2013, USA	Randomized controlled trial	Both patients treated with local lidocaine and pRF showed improved tolerance to pain but without statistical superiority between the two.
	Alanbay et al. (69), 2020, Turkey	Randomized controlled trial	The combination of pRF applied to the SSN and physical therapy was superior to the combination of SSN block and physical therapy.
	Yang et al. (70), 2020, China	Pilot study	pRF of the SSN and the AN achieves similar therapeutic effects as the nerve block. Pulsed radiofrequency modulation is superior in improving the passive ROM of the shoulder.
	Jang et al. (71), 2013, Korea	Randomized controlled trial	pRF of the SSN in patients with chronic shoulder pain was effective, and pain relief for an extended period was sustained in medically intractable shoulder pain patients.
	Tran et al. (72), 2022, USA	Prospective pilot study	Image-guided AN, LPN, and SSN RFA showed minimal complications and is therefore a promising alternative to treat chronic shoulder pain and stiffness from glenohumeral arthritis.
	Ahmed et al. (73), 2019, Cairo	Randomized controlled trial	RFA proved superior to the injection method in managing chronic shoulder pain.

Table 1 (continued). *Radiofrequency Application for Shoulder Pain*

Intervention	Reference	Study design	Results/conclusion
By Radiofrequency in comparison with other methods	Lu et al. (61), 2013, China	Randomized controlled trial	Adding RFA to arthroscopic subacromial decompression showed no significant increase in pain relief, ROM, or functional recovery.
	Korkmaz et al. (74), 2010, Turkey	Randomized controlled trial	The study found no difference in the effect of transcutaneous electrical nerve stimulation and pRF treatment for shoulder pain relief.
	Ökmen et al. (75), 2017, Turkey	Randomized controlled trial	Photobiomodulation therapy and pRF of the SSN showed no superiority over each other.

Note: SSN: suprascapular nerve, AN: axillary nerve, LPN: lateral pectoral nerve, RFA: radiofrequency ablation, PRF: pulsed radiofrequency, ROM: range of motion, IACI: intra-articular corticosteroid injection

with some reporting enormous pain relief lasting at least 5 months and up to a year and others reporting long-term pain relief (52–59). However, not all interventional studies strongly recommend using RFA. For instance, in a study performed in the United Kingdom, RFA was applied to patients with rotator cuff tear arthropathy. There was a temporary remission of pain, which in some cases deteriorated 3 to 6 months following the therapy (60).

In addition to studying RFA for pain management, RFA has been compared with other methods, such as the application of intraoperative RFA in combination with surgery, local anesthetics, corticosteroid injections, conventional transcutaneous electrical nerve stimulation (TENS), and photobiomodulation therapy (PBMT). A clinical trial conducted in China by Lu et al (61) aimed to assess the effectiveness of RFA combined with arthroscopic subacromial decompression (ASD) compared to ASD alone for the management of shoulder pain due to shoulder impingement syndrome. Following the interventions, both treatments showed improvement after 3 months. They concluded that RFA does not improve pain relief in those undergoing ASD surgery (61).

Four studies compared the effectiveness of intraarticular corticosteroid injections (IACI) to that of RFA. All noted an acceptable reduction in pain intensity, but none found one treatment superior to the other (62–65). Furthermore, when IACI was compared with RFA in hemiplegic shoulder pain by Kim et al (63), they concluded that IACI is better at alleviating pain than RFA of the SSN. Nevertheless, RFA is a good alternative when fearing complications following IACI (63). Mermekli et al (65) preferred RFA because it required infrequent repetition of the treatment. In a similar method, injecting steroids before using the RFA technique was tested. Sinha et al (66) and Mermekli et al (65) showed promising results with significant improvement in pain management, but Sinha et al hypothesized that the favorable results were due to the immediate relief caused by steroid injection, and the long-term effect was probably due to RFA alone. Nonetheless, when Gabrhelik et al (67) viewed the topic retrospectively, they found that proceeding with the RFA of the SSN with steroid injections showed no difference in pain management.

In contrast, a double-blinded trial comparing RFA with local anesthetics found that the RFA resulted in more pain control than lidocaine (68). Two studies on hemiplegic shoulder pain by Alanbay et al (69) and Yang et al (70) compared RFA with local anesthetics. Alanbay et al (69) reported greater pain relief in the group undergoing RFA of the SSN, whereas Yang et al (70) noted that both methods produced similar effects. Significant prolonged pain relief for a minimum duration of 6 months was found when injecting a block of the SSN prior to applying the RFA (71,72). RFA of the SSN proved a superior technique compared to the mixture of lidocaine and steroid methods for managing chronic shoulder pain (73).

Lastly, 2 unique studies concerning the shoulder compared the RFA technique on the SSN with 2 infrequently used methods: conventional TENS and PBMT. Korkmaz et al (74) determined that neither the RFA technique nor conventional TENS offered superior pain management (74). Ökmen et al (75), though, concluded that PBMT is more advantageous than pRF therapy, as it is a noninvasive method, and RFA and PBMT showed pain improvement (75).

RFA for Elbow Pain

The elbow joint has 3 articulations: the ulnohumeral, radiohumeral, and radioulnar (76). Although RFA in the shoulder joint has been thoroughly studied, few studies have considered the elbow and wrist joints (Fig. 3). In the elbow, the main focus was lateral epicondylitis. In a clinical trial conducted by Lin et al (77) assessing the improvement of patients with lateral epicondylitis before and after applying the RFA technique to improve pain, the majority reported substantial improvement after multiple follow-ups. Similarly,

Valera–Garrido et al (78) undertook a clinical trial to implement a novel technique for alleviating lateral epicondylitis pain by ultrasound-guided percutaneous needle electrolysis, targeting where thermal lesioning was produced using RFA heat at the origin of the extensor carpi radialis brevis and extensor digitorum communis, after confirming this placement by ultrasound. Following compliance with the management plan, more significant improvements in pain were observed than in the pre-intervention group (78) (Table 2).

RFA for Wrist Pain

The wrist joint is a complicated joint composed of the distal radius, ulna, and the proximal row of carpal bones (scaphoid, lunate, triquetrum, and pisiform) (17). Using RFA for wrist pain alone and comparing it with wrist steroid injections was studied. An interventional study (79) recruited 3 patients with chronic wrist pain. RFA ablation of the posterior and anterior interosseous nerves was performed. After one year of follow-up, 2 of the 3 patients reported significant satisfaction with the outcome, with no documented adverse events or complications. Moreover, a case report in Italy (80) noted a patient with neuropathic pain involving the ulnar side of the forearm, the proximal third of the forearm, and the thumb. The patient failed to respond to conservative methods; thus, he underwent RFA on the median nerve at the wrist level and the ulnar nerve

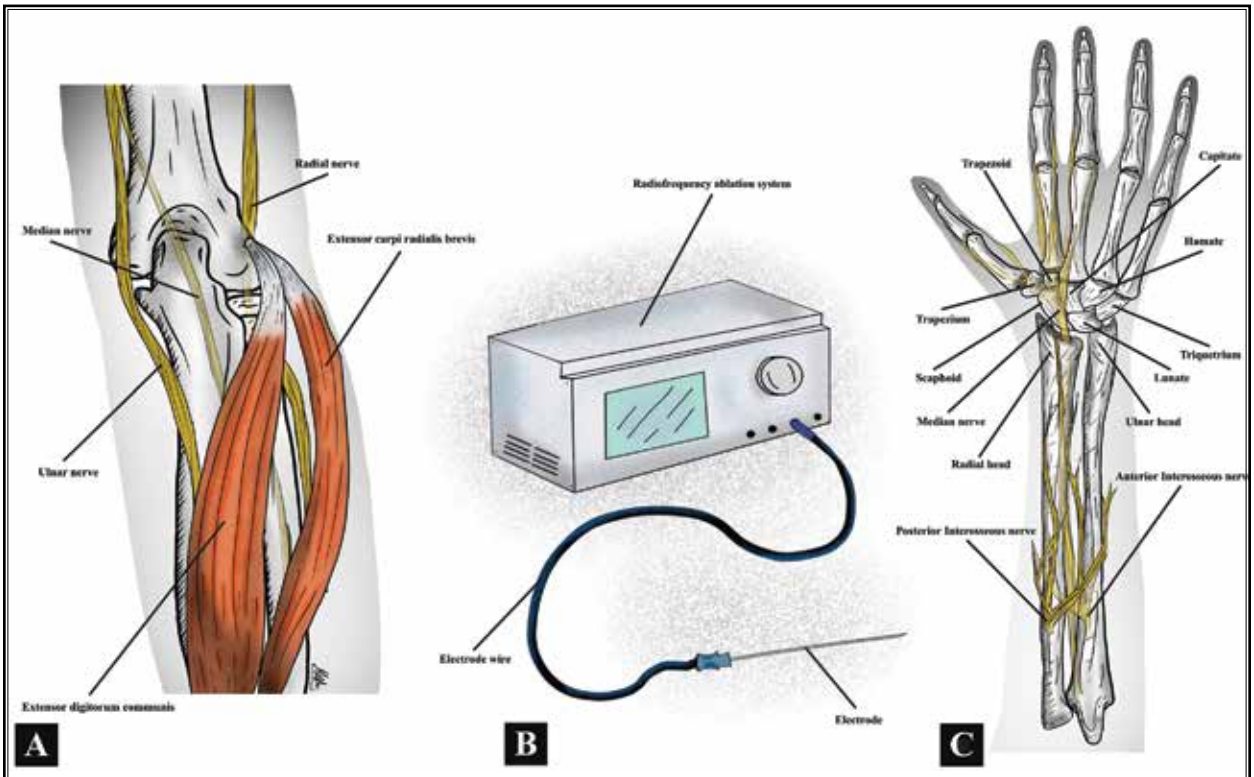

Fig. 3. *Upper limb radiofrequency ablation.*

Table 2. *Radiofrequency application for elbow pain.*

Intervention	Reference	Study design	Results/conclusion
Radiofrequency ablation	Lin et al. (77), 2011, Taiwan	Randomized controlled trial	pRF therapy for patients diagnosed with recalcitrant lateral epicondylitis showed significant pain relief.
	Valera-Garrido et al. (78), 2014, Spain	Clinical trial	Chronic lateral epicondylitis symptoms were reduced following percutaneous needle electrolysis combined with eccentric exercise and stretching.

at the elbow level to control the pain. Following this procedure, the patient showed favorable results, with a 70% reduction in pain (80). Impressively, when the RFA technique was compared with a corticosteroid injection on the median nerve (81), both groups showed promising outcomes, with the RFA group having a significantly shorter duration (Table 3).

Conclusion

RFA is a promising minimally invasive procedure for controlling upper extremity pain. As a solo procedure applied to the shoulder, it showed significant improvement, with a high satisfaction rate. Compared with IACI and local anesthetics, it was more effective than local anesthetics but not superior to IACI. Although studies of the elbow and wrist have not been as extensive as those of the shoulder, they have shown promising results. However, a consideration of possible side effects and complications is warranted. A limitation of our study was the paucity of articles available on its application to the elbow and wrist joints. More articles are necessary for the generalizability of the results.

Table 3. *Radiofrequency application for wrist pain.*

Intervention	Reference	Study design	Results/conclusion
Radiofrequency ablation	Smeraglia et al. (79), 2020, Italy	Review article	pRF of the posterior and anterior interosseous nerves can pose as a conservative alternative to denervation in treating chronic wrist pain.
	Magistroni et al. (80), 2014, Italy	Case report	pRF showed intermediate to long-term pain relief without impairing motor or sensory functions.
Radiofrequency ablation in comparison with steroid injections	Celenlioglu et al. (81), 2022, Turkey	Retrospective study	Corticosteroid injections and pRF showed similar long-term pain relief for carpal tunnel syndrome.

Note: pRF: Pulsed radiofrequency

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