Review Article

# Efficacy of Radiofrequency Lesioning for Chronic Spinal Pain: A Systematic Review

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## Abstract

**Introduction**: Facet joint pain, discogenic pain, sacroiliac joint (SIJ) pain, and radicular pain are chronic spinal pain conditions, where radiofrequency (RF) lesioning has been used so far with variable results. It is always desired to choose a therapeutic option based on its current evidence. The present systematic review has focused on the efficacy of RF lesioning for chronic spinal pain conditions. **Methods**: A literature search was done in PubMed from the year 1966 onward. The basic idea of the literature search was to find out studies focusing on RF lesioning for chronic spinal pain. The randomized controlled trials and observational studies focusing on RF lesioning for chronic spinal pain of more than 3 months duration have been included in this review. **Results:** A total of 286 studies have been identified after literature search and assessed for inclusion in this review. Forty-two of these studies meeting the inclusion criteria have been included for the formulation of evidence; 26 of these studies were of high quality, 14 were of moderate quality, and 2 were of low quality as per Cochrane review criteria score. The level of evidence for RF lesioning of conditions giving rise to nonradicular pain is Level I for continuous RF lesioning of lumbar facet medial branch, for both short- and long-term effectiveness; level II evidence for continuous RF lesioning of cervical facet medial branch, continuous RF or cooled RF lesioning of SIJ and bipolar cooled RF in intradiscal biacuplasty for discogenic pain, for both short- and long-term effectiveness; level III evidence for continuous RF lesioning of thoracic facet medial branch. For radicular pain management, there is Level II evidence for dorsal root ganglion (DRG) pulsed RF lesioning, for both short- and long-term effectiveness. **Conclusion:** The evidence for RF lesioning of chronic spinal pain is summarized as follows:

1. Nonradicular pain.
    a. Cervical facet joint pain: Level II evidence for continuous RF lesioning of cervical facet medial branch.
    b. Thoracic facet joint pain: Level III evidence for continuous RF lesioning of thoracic facet medial branch.
    c. Lumbar facet joint pain: Level I evidence for continuous RF lesioning of lumbar facet medial branch.
    d. Sacro-iliac joint pain: Level II for continuous RF or cooled RF lesioning of SIJ.
    e. Discogenic pain: Level II evidence for bipolar cooled RF in intradiscal biacuplasty for discogenic pain.
2. Radicular Pain: Level II evidence for DRG pulsed RF lesioning for the management of radicular pain.

**Keywords:** Continuous radiofrequency, cooled radiofrequency, disc herniation, discogenic pain, facet joint pain, pulsed radiofrequency, radiofrequency lesioning, sacroiliac joint pain

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## Introduction

Chronic spinal pain is one of the most common causes responsible for hospital visits, work loss, and disability among adult patients across the world;[1] it includes chronic neck, upper back, and low back pain. It affects the performance of an individual both at job-related work and daily activities of living at home; this leads to depression, anxiety, and poor quality of life.[2] A high proportion of people in low-income countries like India are involved in physically demanding jobs which may increase the risk of chronic spinal pain.[3] Hence, it is not surprising that 60% of the Indian population suffers from low back pain at some time during their lifetime.[4]

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Chronic spinal pain results from multiple factors; any spinal structure which has a nerve supply such as muscle, synovial joints, intervertebral discs, dura mater, and ligaments should cause spinal pain.[1] Diagnostic blocks indicate that intervertebral discs, facet joints, sacroiliac joints (SIJs), and nerve roots are the common sources of spinal pain.[5] The structure responsible for spinal pain is targeted by various therapeutic modalities for achieving long-term pain relief. Radiofrequency (RF) lesioning is very commonly used as a therapeutic modality for the management of chronic spinal pain conditions.

RF lesioning interrupts or alters neural transmission in nociceptive fibers; this offers long-lasting pain relief in many conditions giving rise to chronic spinal pain.[6] Two types of RF lesioning are used in chronic pain conditions. Continuous or thermal RF (CRF) generates a thermal lesion along the nociceptive neural pathway; this interrupts the transmission of nociceptive stimuli, offering pain relief.[6] Pulsed RF (PRF) delivers intermittent pulses of current and does not make a thermal lesion in the surrounding tissue; the dense electrical field generated by PRF along the nerve is proposed to reduce the nociceptive transmission.[7] Cooled RF (CoRF) also uses the same principle as that of CRF, but it consists of an active water-cooling system through the electrode to cool down the probe tip, which keeps the adjacent tissue temperature low, and thus prevents tissue desiccation and helps RF energy to advance farther creating larger size lesions.[8]

RF lesioning has been used in a majority of chronic spinal pain conditions; different mechanisms of action of CRF and PRF have laid down different indications for the two types of RF lesioning. CRF is preferred for sensory nerves or mixed nerves with minimal motor supply; PRF because of its nondestructive nature is preferred for mixed sensory-motor nerves.[9] PRF has also been used in conditions where CRF has shown good results; this is in view of lesser side effects associated with PRF owing to its nonablative nature. However, it is suggested that PRF should not be used as a substitute to CRF in conditions where there is good evidence for the role of CRF.[7,10]

Facet joint pain, discogenic pain, SIJ pain, and radicular pain are chronic spinal pain conditions, where RF lesioning has been used so far with variable results. It is always desired to choose a therapeutic option based on its current evidence. The present systematic review has focused on the efficacy of RF lesioning for chronic spinal pain conditions; we hope that this review will enable the pain physicians to take a decision based on present evidence.

## Methods

### Literature search

A literature search was done in PubMed from the year 1966 onwards. The basic idea of the literature search was to find out studies focusing on RF lesioning for chronic spinal pain; we have included studies for both radicular and nonradicular pain in the present review. The disease conditions included for nonradicular pain were facet joint pain, SIJ pain, and discogenic pain; the disease condition included for radicular pain was disc herniation.

Literature search was done with keywords including chronic spinal pain, chronic low back pain, chronic neck pain, chronic upper back pain, chronic mid back pain, chronic thoracic pain, facet joint pain, SIJ pain, discogenic pain, disc herniation, prolapse intervertebral disc, RF, medial branch RF lesioning, RF lesioning, RF ablation, RF neurotomy, CRF, PRF, biacuplasty, annuloplasty, dorsal root ganglion (DRG), ramus communicans lesioning, internal disc disruption and intradiscal.

### Inclusion criteria for the studies

The randomized controlled trials and observational studies focusing on RF lesioning for chronic spinal pain of more than 3 months duration have been included in this review; observational studies have been included for those disease conditions where the number of randomized trials was <5.[11]

### Assessment of study quality

The quality of studies meeting the inclusion criteria was assessed based on Cochrane review criteria score [Table 1];[12] the studies were classified into high-quality (score of 8-12), medium-quality (score of 4-7), and low-quality (score <4) [Table 2]. Only high- and medium-quality studies were included in this review; low-quality studies have been included for those disease conditions where the number of randomized trials was <5.[11]

### Analysis of evidence

The analysis of evidence was based on best evidence synthesis using five levels of evidence[11,13] [Table 3].

## Results

The trials focusing on RF lesioning for chronic spinal pain were carefully identified and reviewed for inclusion in this systematic review; the workflow utilized to identify the trials satisfying the inclusion criteria is shown in Figure 1. The trials included in the review and their efficacy are outlined in Tables 4-15.[14] The evidence has been classified into two categories namely nonradicular and radicular pain; RF lesioning for facet joint, SIJ, and discogenic pain has been considered under the nonradicular pain category, while RF lesioning for DRG giving rise to radicular pain has been considered under radicular pain category.

### Nonradicular pain: Facet joint radiofrequency lesioning

#### *Cervical facet radiofrequency lesioning*

For this systematic review, 29 studies on the use of RF lesioning in cervical facet joint pain were evaluated, and only 4 of them[14-17] met the inclusion criteria. The included studies consisted of two high-quality RCT,[14,17] one prospective observational study[15] of moderate quality, and one nonrandomized comparative study[16] of moderate quality. The description of these studies and their efficacy are outlined in Tables 4 and 10.

There is Level III evidence for both short- and long-term effects for the use of intra-articular PRF for facetogenic pain of the neck, based on the single high-quality RCT[14] included.

**Table 1: Cochrane Review Criteria Scoring System**

| S. No | Study Question | |
|---|---|---|
| A | 1. Was the method of randomization adequate? | Yes/No/Unsure |
| B | 2. Was the treatment allocation concealed? | Yes/No/Unsure |
| C | Was knowledge of the allocated interventions adequately prevented during the study? | |
| | 3. Was the patient blinded to the intervention? | Yes/No/Unsure |
| | 4. Was the care provider blinded to the intervention? | Yes/No/Unsure |
| | 5. Was the outcome assessor blinded to the intervention? | Yes/No/Unsure |
| D | Were incomplete outcome data adequately addressed? | |
| | Was the drop-out rate described and acceptable? | Yes/No/Unsure |
| | 6. Were all randomized participants analyzed in the group to which they were allocated? | Yes/No/Unsure |
| E | 7. Are reports of the study free of suggestion of selective outcome reporting? | Yes/No/Unsure |
| F | Other sources of potential bias | |
| | 8. Were the groups similar at baseline regarding the most important prognostic indicators? | Yes/No/Unsure |
| | 9. Were co-interventions avoided or similar? | Yes/No/Unsure |
| | 10. Was the compliance acceptable in all groups? | Yes/No/Unsure |
| | 11. Was the timing of the outcome assessment similar in all groups? | Yes/No/Unsure |

**Table 2: Study quality classification as per Cochrane Review Criteria Score**

| | Number of studies | | |
|---|---|---|---|
| | High quality (Cochrane score 8-12) | Medium quality (Cochrane score 4-7) | Low quality (Cochrane score <4) |
| Facet joint pain | | | |
| Cervical | 2 | 2 | 0 |
| Thoracic | 1 | 0 | 2 |
| Lumbar | 11 | 4 | 0 |
| SIJ pain | 5 | 2 | 0 |
| Discogenic pain | 3 | 4 | 0 |
| DRG lesioning | 4 | 2 | 0 |
| Total | 26 | 14 | 2 |

DRG: Dorsal root ganglion; SIJ: Sacroiliac joint

Regarding the use of CRF in these patients, for both short- and long-term effectiveness, there is Level II evidence based on one high-quality RCT[17] and two nonrandomized medium-quality studies.[15,16] Considering the variability in the methodology of this limited number of good quality studies, it was difficult to conclude efficiently on the evidence available. Good quality randomized studies in future might help in getting better evidence outcomes.

### *Thoracic facet radiofrequency lesioning*

The evidence for the use of RF lesioning in thoracic facet joint pain is very scarce. 5 studies focussing on the use of RF lesioning in thoracic facet pain were evaluated, and only 3 studies[18-20] met the inclusion criteria for the review, including 1 RCT[20] of high quality and 2 observational retrospective studies[18,19] with low quality according to the Cochrane review criteria score [Table 2]. The included studies are summarized in Table 5.

The results on the efficacy of RF lesioning in this class of pathology are encouraging but very limited [Table 11]. The level of evidence for the use of CRF lesioning of thoracic medial branch Level III for both short-term and long-term effects based on single high-quality RCT.[20] This area needs to be explored more with good quality prospective and randomized trials for getting stronger evidence to conclude efficiently.

### *Lumbar facet radiofrequency lesioning*

A total of 67 studies focusing on lumbar facet RF lesioning were assessed for inclusion in this systematic review. Sixteen studies meeting the inclusion criteria were included in the review;[21-36] of these 12 were of high quality[21,23-28,30,32-35] and 4 were of moderate quality[22,29,31,36] as per Cochrane review criteria score [Table 2]. The study characteristics are summarized in Table 6.

The evidence for the efficacy of thermal RF lesioning in the treatment of lumbar facet joint mediated pain is quite promising [Table 12]. There is Level I evidence for short-term effectiveness (<6 months) for thermal RF lesioning based on 10 high-quality RCTs[21,23-25,27,28,30,32-34] and 3 moderate quality RCTs.[22,29,31] Similarly, there is Level I evidence for long-term effectiveness of thermal RF lesioning (≥6 months), which was derived from 8 high-quality studies[21,24,25,27,28,32-34] and 1 moderate quality study[22] showing sustained improvement in pain and function. However, Tillberg *et al*.[26] did not found any significant benefit of CRF lesioning of the medial branch over the sham group.

There is wide variability in the selection of patients, type of RF used, and target for RF lesioning, employed in different studies. While most of the studies have targeted the medial branch of the dorsal ramus, one high-quality RCT showed good results by targeting the lumbar facet joint capsule[25] and another high-quality RCT showed promising outcomes through intraarticular RF.[24] Majority of the clinical trials have utilized the pillar view technique for the thermal RF ablation of the medial branch.[21,23,27,29-36] The literature is vast for the role of CRF in facetogenic low back pain, but good quality

**Table 3: Grading of level of evidence**

| Level of Evidence | Criteria |
|---|---|
| Level I | Evidence obtained from multiple relevant high quality RCTs |
| Level II | Evidence obtained from at least one relevant high quality RCT or multiple relevant moderate or low quality RCTs |
| Level III | Evidence obtained from at least one relevant moderate or low quality RCT with multiple relevant observational studies |
| Level IV | Evidence obtained from multiple moderate or low quality relevant observational studies |
| Level V | Opinion or consensus of large group of clinicians and/or scientists |

RCT: Randomized controlled trial

**Table 4: Studies included for cervical facet joint radiofrequency lesioning**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Lim 2017[14]*** (*n*=40) | Prospective, randomized, controlled study | Cervical pain without radicular symptoms with positive diagnostic block | IA PRF group (*n*=20): 360 s, at 55 V, electrode tip temperature ≤42°C<br>IA corticosteroid group (*n*=20): 10 mg dexamethasone injected | NRS | 6 months | 50% and 60% of patients in the PRF and steroid group had significant pain relief after 6 months. There was no significant difference between the groups | IA PRF stimulation was as effective as IA steroid injection in patients with cervical facetogenic pain |
| MacVicar 2012[15]** (*n*=104) | Prospective, multicentric outcome study | Consecutive patients who underwent cervical RFN were included | Cervical MB RFN done in all patients (80°C for oblique lesions and 85°C for sagital lesions for 90 s each) | Pain relief, complete restoration of daily activities, no need for further health care, and return to work | 12-30 months | Successful outcome (≥80% pain relief): 74% and 61% patients in the two centres<br>Average duration of pain relief: 17-20 months for first RFN; 15 months for consecutive repeat treatments | Cervical MB RFN can be very effective in appropriately selected patients |
| Sapir 2001[16]** (*n*=46) | Prospective, nonrandomized comparative study | Patients with cervical whiplash with positive two-phase diagnostic cervical MBB | Nonlitigation Group (*n*=18): RFA of MB of cervical facet done at 80°C for 90 s<br>Litigation group (*n*=28): RFA of MB of cervical facet at same RF settings | VAS<br>Self-reported improvement<br>Pretreatment and posttreatment medication usage | 1 year | All symptoms had significant reduction immediately after treatment and at 1 year follow-up in both groups<br>1 year follow-up VAS was higher than immediate posttreatment score<br>The difference between groups was not significant | Cervical MB RFN is effective for treatment of cervical facet pain<br>Potential of secondary gain doesn't influence treatment response in cervical whiplash injury patients |
| Lord 1996[17]*** (*n*=24) | Prospective, RCT | Painful C3-4 to C6-7 facet joints with single diagnostic block | RFN group (*n*=12): 2-3 lesions at 80°C for 90 s each along medial branch of cervical dorsal ramus<br>Control group (*n*=12) | VAS<br>McGill pain questionnaire | 12 months and then yearly follow-up | The median time of significant pain relief was 263 days in RFN group and 8 days in control group (*P*=0.04)<br>At 27 weeks, 7 patients in RFN group and one patient in control group were free of pain | In patients with chronic cervical facet-joint pain, RFN with multiple lesions of medial branch can provide lasting relief |

**Medium quality studies; ***High quality studies. IA: Intra-articular; RF: Radiofrequency; PRF: Pulsed RF; MB: Medial branch; MBB: MB block; NRS: Numeric rating scale; RFA: RF ablation; RFN: Radio frequency neurotomy; VAS: Visual analogue scale; RCT: Randomized controlled trial

studies for evidence of cooled or pulsed RF are limited. In our review, we found one high-quality RCT that reported cooled RF was as effective as thermal RF,[21] one high-quality RCT that concluded intraarticular PRF to be as effective as intraarticular steroids[24] and 1 moderate quality RCT that showed PRF is not as effective as CRF in facetogenic low back pain.[32]

## Nonradicular pain: Sacro-iliac joint radiofrequency lesioning

Fifty-seven studies focussing on RF denervation for SIJ pain were evaluated. 7 RCTs[37-43] meeting the inclusion criteria were included in this review; 5 of them[37,39,40,42,43] were of high quality and 2 studies had a moderate quality[38-41] as per Cochrane review criteria score [Table 2]. The included studies and their efficacy have been outlined in Tables 7 and 13 respectively.

CRF, PRF, and CoRF had all been used for the management of SIJ pain in the presently available trials. There is high degree of nonuniformity in the RF modality, lesioning parameters, and target sites used in the limited number of trials available for the management of SIJ pain via RF lesioning; hence, it was difficult to suggest a clear level of evidence for each type of RF used in the management of SIJ pain. There is Level II evidence

**Table 5: Studies included for thoracic facet joint radiofrequency lesioning**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Gungor 2020[18]* (*n*=23) | Retrospective cohort study | Upper or mid back pain caused by thoracic facet joints as confirmed by dual diagnostic thoracic MBB | CoRF neurotomy of thoracic MB (60°C for 150 s)<br>No control group | NRS<br>Average percent improvement from baseline time to repeat CRF | 12 months | Improvement of NRS was 20.72% (4-8 weeks), 53% (2-6 months) and 37.58% (6-12 months) | CoRF neurotomy of thoracic MB is effective for thoracic facet pain |
| Rohof 2018[19]* (*n*=71) | Retrospective record review | Thoracic facet joint pain identified with single diagnostic thoracic MBB | Bipolar RFN of thoracic MB (one lesion at each level at 60°C for 150 s)<br>No control group | NRS<br>PDI | 12 months | NRS decreased significantly from baseline at 3 months and at 12 months postprocedure<br>The PDI also improved significantly | Bipolar RFN of thoracic MB is effective in reducing pain and disability in thoracic facet joint pain |
| Joo 2013[20]*** (*n*=40) | Prospective, randomized controlled trail | Recurrent thoraco-lumbar facet pain with previous successful RFA, with dual positive comparative diagnostic block | Group I (*n*=20): MB RFA (one lesion at each level at 90°C for 90 s)<br>Group II (*n*=20): Dehydrated alcohol injection to MB nerve | NRS<br>ODI | 24 months | The median effective periods were 10.7 and 24 months for Group I and II respectively<br>After 24 months follow-up, 1 and 17 patients respectively were having significant relief in Group I and Group II | Alcohol ablation in comparison to RF neurotomy of thoracic MB provided a longer period of pain relief and better QOL in recurrent thoracolumbar facet joint pain syndrome |

*Low quality studies; ***High quality studies. RF: Radiofrequency; CoRF: Cooled RF; CRF: Continuous RF; MB: Medial branch; MBB: MB block; NRS: Numeric rating scale; ODI: Oswestry disability index; RFN: Radiofrequency neurotomy; RFA: RF ablation; PDI: Pain disability index; QOL: Quality of life

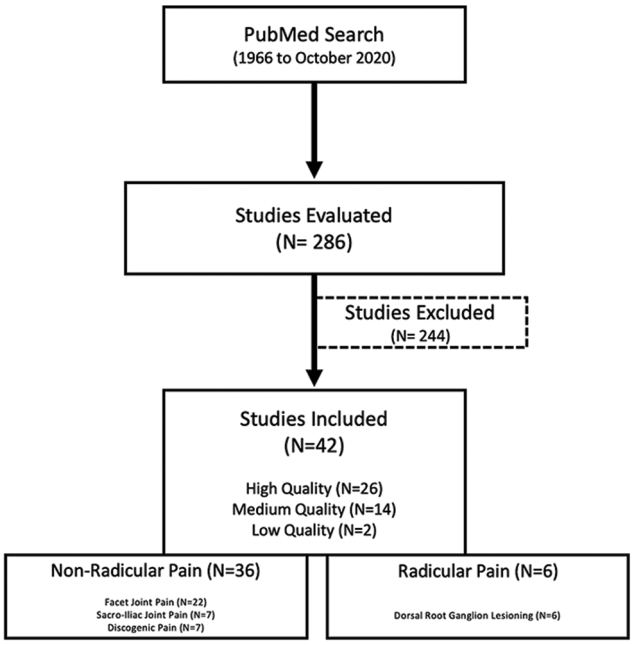


**Figure 1:** Flow diagram: Methodology used for the literature search

available for both short- and long-term efficacy of CRF (2 moderate quality RCTs and one high-quality RCT)[38,41-43] and cooled RF (2 high-quality RCTs)[40,42] in the management of SIJ pain; one high-quality RCT[37] also supported the role of PRF lesioning for SIJ pain.

## Nonradicular pain: Radiofrequency lesioning for discogenic pain

Seventy-six studies regarding the use of RF lesioning in discogenic pain were assessed for this systematic review, and 7 studies[44-50] meeting the inclusion criteria have been included in the review. Among the included studies, all were RCTs of high[46,47,50] to moderate quality[44,45,48,49] as per Cochrane review criteria score [Table 2]. The included studies and their efficacy are tabulated in Table 8 and Table 14.

The role of bipolar CoRF in intradiscal biacuplasty (IDB) for discogenic pain has been found to be efficacious for both short (<6 months) and long term (6 months) by one high quality[46] and one moderate quality[44] RCT; hence, as per the review a Level II evidence for the use of bipolar CoRF in IDB for discogenic pain. Among other RF modalities for discogenic pain a role of CoRF lesioning of ramus communicans nerve for disc-related pain has been suggested by a single moderate-quality RCT,[48] with short term efficacy (4 months). The role of intradiscal CRF lesioning for discogenic pain has been supported by one moderate-quality RCT[49] and declined by a high-quality RCT;[50] the role of intradiscal electrothermal therapy (IDET) in discogenic pain has been negated by Freeman *et al*. in a high-quality RCT.[47]

There is a major diversity in the type of current and lesion parameters of the intradiscal RF lesioning used in discogenic pain. The role of a definitive RF lesioning modality is yet to be established.

**Table 6: Studies included for lumbar facet joint radiofrequency lesioning**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| McCormick 2019[21]*** (*n*=39) | Single-blinded, prospective, randomized, comparative trial | Facetogenic LBP with a single positive diagnostic block | Intervention (*n*=18): T-RFA for 90 s at 80°C<br>Control (*n*=21): CoRFA for 165 s at each MB nerve at 60°C | NRS<br>ODI<br>PGIC | 1, 3 and 6 months | ≥50% NRS reduction was observed in 52% and 47% of participants in CoRFA and T-RFA groups, respectively and ≥15-point or ≥30% reduction in ODI score was observed in 62% and 42% of participants in CoRFA and T-RFA groups, respectively, at 6 months follow up | No significant differences were observed between the two RFA modalities in terms of NRS, ODI and PGIC |
| Song 2019[22]** (*n*=40) | RCT | Patients with chronic LBP following double diagnostic block | Intervention (*n*=20): EN with bipolar radiofrequency<br>Control (*n*=20): RFN with 2 cycles of RF thermocoagulation at 80°C for 90 s | VAS<br>ODI | 3 weeks, 6 months, 1, and 2 years | The RN group showed effects till 1 year of follow up, while the EN group showed effects till 2 years of follow up<br>The EN group showed better results as compared to the RN group from 6 weeks onwards | EN provides better and longer effects than RN of lumbar MB in chronic LBP of facetogenic origin |
| Cohen 2018[23]*** (*n*=229) | RCT | Chronic LBP patients | Group I (*n*=91): RF lesioning done after positive IA diagnostic block<br>Group II (*n*=91): RF lesioning done after positive MBB diagnostic block<br>Group III (*n*=47): RF lesioning done after placebo diagnostic block | NRS<br>ODI<br>Medication reduction<br>Patient Satisfaction | 1, 3 and 6 months | At 3 months, the proportions of positive responders in the IA, MBB, and placebo groups were 51%, 56%, and 24% respectively | Treatment group in this study had better response rate than placebo suggesting that diagnostic blocks have prognostic value if done before RF ablation |
| Do 2017[24]*** (*n*=60) | RCT | Axial LBP following a positive IA diagnostic block | IA PRF group (*n*=30): PRF done at 55 V for 360 s<br>ICI group (*n*=30): 10 mg (0.25 mL) dexamethasone mixed with 0.25 mL of 0.125% bupivacaine used | NRS Score | 2 weeks, 1, 3, and 6 months | Both groups showed a significant decrease in NRS scores at all times of follow-up<br>ICI group had significantly lower NRS scores than the PRF group at 2 weeks and 1 month; thereafter the two groups had similar results | IA PRF is a useful therapeutic option for the management of facetogenic pain |
| Moussa 2016[25]*** (*n*=120) | Prospective, double blinded RCT | Chronic LBP following dual diagnostic MB block | Group I (*n*=40): 2 RF lesions in each facet joint capsule (850°C for 90 s)<br>Group II (*n*=40): 3 RF lesions along the course of the MB (same settings)<br>Group III (*n*=40): Sham group; RF lesioning not done<br>All the groups received bupivacaine 0.5% and 20 mg depot methylprednisolone injection (total volume=1 ml) at the end | COM comprising VAS, ODI and analgesics consumption | 3 months, 1, 2 and 3 years | 3 months: Improvement in VAS was significantly better in all groups<br>1 year follow-up: Group I and II maintained improvement<br>2 and 3 years follow-up: only Group I (joint capsule RF) maintained significant improvement | RFA of facet joint capsule provides an easier technique with an extended period of pain relief compared to RFA of MB of dorsal ramus |

*Contd...*

**Table 6: Contd...**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| van Tilburg 2016[26]*** (*n*=60) | RCT | Facet joint arthropathy following a diagnostic block | Intervention (*n*=30): RFA of MB at 80°C for 60 s<br>Control (*n*=30): Sham group; RF lesioning not done | NRS, GPE scale | 1 and 3 months | RFA, when compared to sham group, significantly reduced pain up to 1 month period. However, there was no significant difference between the groups beyond that time | RFA of the MB has no significant benefit over sham group |
| Arsanious 2016[27]*** (*n*=47) | Prospective, double-blinded, RCT | Low back pain diagnosed as facet joint disease by dual diagnostic blocks | PRF group (*n*=26): PRF followed by CRF<br>CRF group (*n*=21): RFA at 80°C for 90 s | Postprocedural pain levels using NRS and consumption of oral analgesics in the first 48 h | 2 days | Patients in PRF + thermal RF group demonstrated statistically significantly lower pain scores till morning of next postprocedure day with no difference beyond that time period. Analgesic intake was also less in that group but the difference was not statistically significant | Use of PRF before thermal RF reduces the postprocedure pain during the first 24 h |
| Moon 2013[28]*** (*n*=82) | Prospective, randomized, active control study | Patients with positive response to dual diagnostic blocks | Intervention (*n*=41): RFA at 80°C for 90 s by utilizing a distal approach for facet denervation<br>Control (*n*=41): RFA (same settings) with the needle placed by a tunnel vision approach (parallel to nerve) | NRS, ODI | 1 and 6 months | Both groups showed a statistically significant reduction in NRS and ODI at 1 and 6 months<br>However, procedure-related pain score was significantly lower in distal approach group | Both approaches for RFA have been found to be equally effective<br>Distal approach may be preferred owing to lower postprocedure pain |
| Lakemeier 2013[29]** (*n*=50) | Randomize, controlled, double-blind trial | Pain relief ≥50% after LA injection into osteoarthritic lower facet joints identified by MRI | Intervention (*n*=26): RFA of MB done at 80°C for 90 se<br>Control (*n*=24): IA injection of steroids with 0.5 mL of 0.5% bupivacaine and 1 mL of betamethasone (3 mg) | RMQ, VAS and ODI | 6 months | Pain relief and functional improvement were observed in both groups without any significant differences between groups | Both IA steroid and RFA appear to be equally effective in managing facetogenic LBP |
| Roy 2012[30]*** (*n*=34) | Prospective clinical trial | Patients included after dual diagnostic blocks | Intervention (*n*=34): CRF of MB at 85°C for 90 s done for 3 times at each target nerve; followed by infiltration of 20 mg methylprednisolone acetate<br>Control: No control group | NRS, RMQ | 1, 2, 6 months and 1 year | NRS showed pain relief of 85%, 65%, 78%, 62%, and 59.5% at immediate postprocedure, 1, 2, 6 months, and 1 year respectively | RFA combined with steroid infiltration produced substantial improvement of pain and function in short term as well as long term |
| Cohen 2010[31]** (*n*=151) | Randomized active control trial | Axial LBP ≥3 months duration, refractory to conservative therapy | Group I (*n*=50): RFA done after single diagnostic block<br>Group II (*n*=50): RFA done after dual blocks<br>Group 0 (n=51): RFA done based on clinical findings | NRS at rest and activity, ODI, GPE and cost per successful outcome | 1 and 3 months | Successful outcome at 3 months was present in 33% (Group 0), 16% (Group I) and 22% (Group II). Denervation success rates were 33%, 39%, and 64% respectively<br>NRS and functional capacity were significantly better at 3 months but not at 1 month in Group II subjects | Dual diagnostic blocks results in the highest success rate for RFA. But proceeding to RFA without performing a diagnostic block is more cost-effective |

*Contd...*

**Table 6: Contd...**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Kroll 2008[32]*** (*n*=26) | Randomized, double-blind study | Patients included after dual diagnostic blocks of MB | PRF group (*n*=13): PRF for 120 s<br>CRF group (*n*=13): CRF at 80°C for 75 s | VAS and ODI | 3 months | Both groups were similar in relative improvements in either VAS or ODI<br>In CRF group, VAS and ODI showed significant improvement over 3 months | CRF showed better improvement in outcome measures than PRF |
| Buijs 2004[35]*** (*n*=33) | Non-RCT | LBP with a positive diagnostic IA facet joint blocks | Voltage controlled group (*n*=16): RF at 20 V, 60 s; 63 lesions done<br>Temperature controlled group (*n*=17): RF at 80°C for 60 s; 55 lesions done | Electrophysiologic parameters during lesioning as seen on RF generator | No follow-up | All lesions in the temperature controlled group were judged technically adequate<br>In the voltage controlled group, 44 out of 63 (69.8%) procedures were found to be inadequate | Temperature controlled setting is preferable for RFA |
| van Kleef 1999[36]** (*n*=31) | Randomized, double-blind, sham control trial | LBP ≥1 with single diagnostic block | Intervention (*n*=15): CRF at 80°C for 60 s after LA injection<br>Control (*n*=16): Only LA injection after needle placement | VAS, GPE, ODI | 3, 6, and 12 months | The number of successful outcomes in the RF and sham groups was 60% and 25%, 47% and 19%, and 47% and 13% respectively after 3, 6 and 12 months of follow up<br>All differences were statistically significant | CRF is efficient in management of facetogenic pain |

**Medium quality studies; ***High quality studies. RF: Radiofrequency; CRF: Continuous RF; LA: Local anaesthetic; LBP: Low back pain; ODI: Oswestry disability index; RFA: RF ablation; VAS: Visual analogue scale; GPE: Global perceived effect; NRS: Numerical rating scale; SF-36: Short form (36) health survey; MRI: Magnetic resonance imaging; RMQ: Roland-Morris Questionnaire; IA: Intra-articular; PRF: Pulsed RF; MB: Medial branch; MBB: MB Block; TRFA: Traditional RFA; CoRFA: Cooled RFA; PGIC: Patient global impression of change; RCT: Randomized controlled trial; EN: Endoscopic neurotomy; RN: Radiofrequency neurotomy; ICI: IA corticosteroid injection; COM: Combined outcome measure

## Radicular pain: dorsal root ganglion radiofrequency lesioning

A total of 51 studies focusing on RF lesioning of DRG for radicular pain were assessed for inclusion in this systematic review. 6 studies meeting the inclusion criteria were included in the review;[51-56] out of these 4 were of high quality[50,54-56] and 2 were of moderate quality[52,53] as per Cochrane review criteria score [Table 2]. The study characteristics are summarized in Table 9.

The evidence for the efficacy of RF lesioning of DRG, in the treatment of spinal radicular pain, is encouraging [Table 15]. There is Level II evidence for short-term effectiveness (<6 months) of DRG PRF lesioning, based on 2 high-quality RCTs[51,54] and 2 moderate quality RCTs.[52,53] Similarly, there is Level II evidence for long-term effectiveness of DRG RF lesioning (≥6 months), derived from one high-quality study[51] and one moderate quality study[52] that showed persistent improvements in pain and function.

The literature is more convincing for the role of PRF lesioning of DRG in comparison to CRF, in the management of radicular pain. There are four moderate-to high-quality RCTs[51-54] substantiating the effectiveness of PRF, two of which concluded that the benefits were maintained even in long term.[51,52] However, out of two high-quality RCTs for CRF lesioning of DRG, one has suggested only short-term benefits in improving radicular pain[56] whereas the other has established it as ineffective in both short term and long term.[55]

Another important fact regarding DRG RF lesioning for radicular lesioning was better results for lumbosacral radicular pain in comparison to cervical radicular pain; DRG RF lesioning has contributed to long-term benefits for lumbar radicular pain[51,52] in comparison to short-term benefits for cervical radicular pain.[54,56] Hence, good quality randomized studies are warranted in future to determine the efficacy of DRG RF, especially for cervical radicular pain.

## Discussion

The present systematic review has analyzed the literature related to RF lesioning for chronic spinal pain conditions. The first step in the management of any chronic spinal pain condition is the identification of a cause giving rise to chronic spinal pain; usually, this is done in the form of a local anesthetic diagnostic block. The next step is to utilize therapeutic options

**Table 7: Studies included for Sacro-Iliac Joint radiofrequency lesioning**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Dutta 2018[37]*** (*n*=30) | Prospective, randomized trial | SIJ dysfunctional pain confirmed by diagnostic block | Group I: IA methylprednisolone<br>Group II: PRF | NRS<br>ODI<br>GPE | 6 months | NRS scores: Decreased in both groups at 15 days follow-up; at 6 months improvement was maintained only in PRF group<br>ODI scores and GPE responses: Significantly better in PRF group only | PRF lesioning of L4 and L5 primary dorsal rami and S1-3 lateral branches were more effective than IA steroid injection |
| Mehta 2018[38]** (*n*=17) | Prospective, double-blinded, RCT | Patients with SIJ pain following a diagnostic block | Active treatment group: RFN for SIJ innervation<br>Sham group: Identical procedure without using RF | NRS<br>SF-12<br>HADS | 6 months | NRS: Decreased in active group only<br>Similar results were seen for other outcome measures also | Strip lesioning RF lesioning is an effective therapy to treat SIJ pain |
| van Tilburg 2016[39]*** (*n*=60) | Prospective, double-blinded, RCT | A decrease of ≥2 points on NRS (scale of 0-10) after a diagnostic SIJ block | Treatment group: RF heat lesion of nerves supplying SIJ<br>Sham group: Same procedure except for RF heat lesion | NRS<br>GPE | 12 months | No statistically significant difference in NRS score over time between two groups observed (*P*=0.56)<br>For GPE also, the difference between the groups was not significant (*P*=0.15) | No benefit of RFN over sham treatment in patients with SIJ pain |
| Patel 2016[40]*** (*n*=51) | Prospective, RCT | SIJ pain following dual diagnostic block | CRF/LBN group: CoRF-mediated LBN<br>Sham group: Sham procedure; participants were permitted to receive CRF/LBN; crossover study subjects | NRS<br>SF36-BP<br>ODI<br>SF36-PF | 12 months<br>6 additional months for cross over subjects | CRF/LBN group: Outcomes improved as compared to baseline<br>Crossover study group: Favorable outcomes at 6 months follow-up | CRF/LBN is effective for the management of SIJ pain |
| Zheng 2014[41]** (*n*=155) | RCT | Ankylosing spondylitis patients with significant SIJ pain | Group I: PSRN<br>Group II: Celecoxib treatment (400 mg/day for 24 weeks) | VAS<br>Physical function<br>Spinal mobility | 24 weeks | VAS: Significantly reduced in both groups 12 and 24 weeks<br>PSRN was more effective in improving pain scores, physical function and spinal mobility | PSRN was superior to celecoxib in improving pain scores and other outcome measures |
| Patel 2012[42]*** (*n*=51) | Prospective, randomized trial | SIJ pain following dual diagnostic block | CRF/LBN group: CoRF-mediated LBN<br>Sham group: Sham procedure | NRS<br>SF36-BP<br>ODI<br>SF36-PF | 9 months | CRF/LBN group: Favourable outcomes at 3, 6 and 9 months | CRF/LBN is effective for the management of SIJ pain |
| Cohen 2008[43]*** (*n*=28) | Randomized, placebo-controlled study | SIJ pain following diagnostic block | Treatment group: CRF of L4-L5 dorsal rami and CoRF of S1-3 lateral branch<br>Placebo group: LA block followed by sham procedure | NRS<br>ODI<br>Reduction in analgesic use<br>GPE | 6 months | Treatment group: ≥50% pain relief and clinically relevant functional improvement at 1 (79%), 3 (64%) and 6 (57%) months follow up; efficacy significantly better than placebo group | CRF with CoRF was found useful in the management of SIJ pain |

**Medium quality studies; ***High quality studies. CoRF: Cooled RF; CRF: Continuous RF; IA: Intra-articular; GPE: Global perceived effect; LBP: Low back pain; NRS: Numerical rating scale; ODI: Oswestry disability index; RF: Radiofrequency; PRF: Pulsed RF; RFN: Radiofrequency neurotomy; VAS: Visual analogue scale; SIJ: Sacro-Iliac Joint; RCT: Randomized controlled trial; SF-12: 12-item short form health survey; HADS: Hospital and depression scale; LBN: Lateral branch neurotomy; SF36-BP: SF 36-bodily pain; SF36-PF: SF 36-physical functioning; PSRN: Palisade sacroiliac joint RF neurotomy; LA: Local anaesthetic

offering long-term pain relief; RF lesioning is one such modality which is very commonly used in the field of chronic pain to offer long-term benefits. RF lesioning offers variable efficacy in different chronic pain conditions. Hence, it is wise to choose RF lesioning as a therapeutic option for any chronic spinal pain condition based on the evidence available in the current literature; this review is an attempt in this direction.

The efficacy of RF lesioning depends on a number of variables including type of RF; lesion parameters temperature, duration, and voltage used for lesioning; needle and active tip dimensions; single or dual diagnostic blocks before RF lesioning; target site used for lesioning and needle orientation with respect to the nerve. Different parameters have been used in different studies based on the availability of RF generator,

**Table 8: Studies included for radiofrequency lesioning for discogenic pain**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Desai 2017[44]** (*n*=60) | Follow up study of a randomized, cross-over, multicentre trial | Follow up patients of Desai *et al*.[45] | Group I (n=22): IDB (as that of Desai *et al*.[45]) + CMM<br>Group II (*n*=3): CMM alone<br>Crossover group (*n*=25): IDB + CMM after 6 months of CMM alone | VAS<br>SF36-PF<br>ODI<br>BDI<br>Analgesic usage | 12 months | Improvement in all outcome measures were present in the original IDB + CMM group compared to baseline<br>50% of cross-over subjects responded to IDB + CMM intervention | Long-term clinical effectiveness of IDB + CMM for treating chronic lumbar discogenic pain |
| Desai 2016[45]** (*n*=63) | Prospective, randomized controlled, multicentre trial | Definite single level provocative discography | Group I (*n*=29): IDB + CMM; IDB: Bipolar CoRF (at 50°C for 15 min) followed by individual monopolar lesions (at 60°C for 2.5 min)<br>Group II (*n*=34): CMM alone | VAS<br>SF36-PF<br>ODI<br>BDI<br>Analgesic usage | 1, 3, and 6 months | In the Group I, mean VAS reduction was more than group II (P=0.02)<br>Differences in secondary measures also favored IDB<br>Opioid consumption was similar in both groups | Superior performance of IDB when combined with CMM than CMM alone for the treatment for discogenic pain |
| Kapural 2013[46]*** (*n*=59) | Randomized, placebo-controlled, double-blinded, multicentre trial | Evidence of 1- or 2-level degenerative disc disease with positive provocative discography | IDB group (*n*=29): Bipolar CoRF (*n*=13; 45°C for 15 min); Bipolar CoRF (*n*=16; 50°C for 15 min) followed by monopolar RFA around electrode (at 60°C for 2.5 min)<br>Sham group (*n*=30) | SF-36<br>NRS<br>ODI | 1, 3, and 6 months | IDB group exhibited statistically significant improvements as compared to sham group<br>No difference in outcome in the 2 RF settings of IDB group | The treatment effects provided by IDB are nonplacebo effects and are an effective modality for discogenic pain |
| Freeman 2005[47]*** (*n*=57) | Randomized, double-blind, placebo-controlled trial | Positive provocative CT discography for 1- or 2- levels | IDET group (*n*=38 patients): At 65°C rising over 12.5 min to 90°C and held for 4 min<br>Sham group (*n*=19) | ODI<br>SF-36<br>Depression index<br>Modified Somatic Perceptions Questionnaire | 6 weeks and 6 months | No subject in either arm showed any statistically significant improvement in any of the outcome measures | No significant benefit from IDET over placebo in patients of chronic discogenic low back pain |
| Oh 2004[48]** (*n*=49) | Prospective, randomized, controlled trial | Patients with discogenic pain with positive diagnostic block of ramus communicans | Lesion group (*n*=26): RFA of ramus communicans nerve (at 65°C for 60 s)<br>Control group (*n*=23) | VAS<br>SF-36<br>Analgesic requirement<br>Treatment satisfaction scores | 4 months | All the outcome measures were significantly better in lesion group | Percutaneous RFA of ramus communicans nerve can be considered as a treatment option for discogenic LBP |
| Erçelen 2003[49]** (n=39) | Prospective randomized trial | Patients with positive provocative discography | Group A (*n*=19): RFA of involved disc at 80°C for 120 s<br>Group B (*n*=18): RFA of involved disc at 80°C for 360 s | VAS<br>ODI | 1 and 2 weeks, at 1, 3, and 6 months | Both groups had significant improvement on follow ups till 3 months<br>At 6 months, improvement was not significant in both groups (*P*>0.05) | Percutaneous intradiscal RFA relieves discogenic pain. Increasing lesion duration does not increase efficacy |

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**Table 8: Contd...**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Barendse 2001[50]*** (n=28) | Prospective, double-blind, randomized trial | Patients with positive analgesic discography at single level | RF treatment group (*n*=13): At 70°C for 90 s<br>Control group (*n*=15) | VAS<br>ODI<br>Analgesic tablet intake<br>QOL | 8 weeks | Only 1 and 2 successful outcome patient in RFA and control group respectively. There was no statistically significant difference between the two groups | Percutaneous intradiscal RFA is not effective in reducing chronic discogenic LBP |

**Medium quality studies; ***High quality studies. IDB: Intradiscal biacuplasty; RF: Radiofrequency; RFA: RF ablation; NRS: Numerical rating scale; VAS: Visual analogue scale; SF36-PF: Short form 36-physical functioning; ODI: Oswestry disability index; BDI: Beck depression inventory; CoRF: Cooled RF ablation; IDET: Intradiscal electrothermal therapy; LBP: Low back pain; CMM: Conventional medical management; CT: Computed tomography; QOL: Quality of life

**Table 9: Studies included for radiofrequency lesioning of dorsal root ganglion (for radicular pain)**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| De 2019[51]*** (*n*=50) | Prospective, triple-blind, randomized, active-control trial | Lumbar radicular pain patients with a positive diagnostic selective nerve root block | Intervention (*n*=25): LPRF of DRG, 3 cycles at 2 Hz, 45 V, for 180 s each, followed by LA injection of 1 ml 0.5% bupivacaine.<br>Control (*n*=25): Transforaminal epidural injection of 1 ml 0.5% bupivacaine | VAS<br>ODI | 2 weeks, 1, 2, 3, 6 months | LPRF group had better outcome at all follow-up points<br>At 3 and 6 months positive responders were 98% and 28%, respectively, in LPRF group, whereas it was 0% in LA group | PRF of DRG, when applied for longer duration, results in significant long-term improvement in pain and QOL |
| Lee 2018[52]** (*n*=60) | Randomized prospective comparative study | Axial LBP with/ without lower limb pain | Group I (*n*=30): DRG PRF (100 V, 42°C, for 4 min) done after a positive diagnostic DRG block (LA + steroid)<br>Group II (*n*=30): DRG PRF done based on clinical findings alone | NRS<br>ODI<br>Patient satisfaction<br>Analgesic consumption | 2 weeks, 1, 3, 6 months | At 6 months follow-up, 20 patients in Group I and 25 patients in Group II had a successful outcome<br>Medical cost was significantly less in Group II | DRG diagnostic block before DRG PRF has no role in improving outcome and is not cost-effective |
| Simopoulos 2008[53]** (*n*=76) | Randomised prospective pilot study | Lumbosacral radicular pain, with complete relief after 3 diagnostic selective nerve root blocks | PRFL group (n=37): PRF Lesioning of DRG at 42°C, 45 V for 120 s<br>PRFL + CRFL group (n=39): PRF of DRG followed by CRF lesioning at (~54°C + 5°C) for 60 s | VAS<br>Complications | Monthly for 8 months | Treatment success (defined at 8 weeks) was similar in both groups<br>Average duration of pain relief was 3.18 months (PRFL group) and 4.39 months (PRFL + CRFL) | PRF of DRG has good short-term benefit for radicular pain<br>The addition of CRF did ot give added benefits |
| Van Zundert 2007[54]*** (*n*=23) | Double-blind sham-controlled randomized clinical trial | Cervical radicular pain with 3 positive diagnostic DRG blocks | Intervention (*n*=11): PRF of DRG for 120 s<br>Control (*n*=12): Sham procedure, no current passed | VAS<br>GPE<br>QOL<br>Analgesic consumption | 4 weeks, 3, 6 months | 4 weeks: Sham group had better outcome<br>3 months: PRF group had significantly better improvement in VAS, GPE, and Domain vitality of QOL<br>6 months: Statistical significance lost for VAS/ GPE/QOL; but PRF group had less analgesic consumption | PRF of cervical DRG can be a very effective modality for radicular pain, in carefully selected patients |

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**Table 9: Contd...**

| First author, year | Study design | Inclusion criteria | Study groups | Outcome measures | Follow-up period | Results | Conclusions |
|---|---|---|---|---|---|---|---|
| Geurts 2003[55]*** (*n*=83) | Randomised, double-blind, controlled trial | Lumbosacral radicular pain with predominant lower limb pain, with 3 positive selective nerve root blocks | Intervention (*n*=45): CRF of DRG (670°C for 90 s) done after injecting 3-5 ml 2% mepivacaine<br>Control (*n*=38): Same volume of mepivacaine injected, but no current passed | VAS<br>NRS<br>SF-36<br>Analgesic consumption | 3, 6, 9, 12 months | 3 months: Successful outcome was present in 16% (RF group) and 25% patients (control group)<br>No significant differences in the outcome measures between the groups; a higher proportion of control group patients had successful outcome until 12 months of follow up | For lumbosacral radicular pain, CRF of DRG failed to show an advantage over control treatment with LAs |
| Slappendel 1997[56]*** (*n*=61) | Randomized prospective double blinded study | Cervical radicular pain refractory to conservative measures/trigger point or facet interventions; with positive diagnostic nerve root block | Intervention (*n*=32): CRF of DRG at 670°C for 90 s after 2 ml 2% lidocaine injection<br>Control (*n*=29): RFA of DRG at 400°C for 90 s after 2 ml 2% lidocaine injection | VAS, subjective changes, adverse effects | 6 weeks, 3 months | At 3 months, VAS reduced significantly compared to baseline, in both groups<br>No significant difference between the groups, in the proportion of patients who achieved VAS reduction of >3 points; no difference in the incidence of adverse effects | RFA of cervical DRG with 40°C is equally effective as treatment at 670°C, for management of cervical radicular pain |

**Medium-quality studies; *** High-quality studies. RF: Radiofrequency; CRF: Continuous RF; CRFL: Continuous RF lesioning; LBP: Low back pain; LA: Local anesthetic; PRF: Pulsed RF; LPRF: Lumbar PRF; NRS: Numerical rating scale; ODI: Oswestry disability index; PRFL: Pulsed RF lesioning; QOL: Quality of life; VAS: Visual analog scale; GPE: Global perceived effect; RFA: RF ablation; DRG: Dorsal root ganglion

**Table 10: Efficacy of trials of cervical facet joint radiofrequency lesioning**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| Lim *et al*., 2017[14]*** (*n*=40) | IA PRF group (*n*=20): 360 s, at 55 V, electrode tip temperature ≤42°C<br>IA corticosteroid group (*n*=20): 10 mg dexamethasone | Present in both groups | Present in both groups | Both methods effective for both short and long terms of follow-up |
| MacVicar *et al*., 2012[15]** (*n*=104) | Cervical MB RFN done in all patients (80°C for oblique lesions and 85°C for sagittal lesions for 90 s each) | Present in both groups | Present in both groups | Cervical MB RFN can be very effective treatment modality |
| Sapir and Gorup 2001[16]** (*n*=46) | Nonlitigation Group (*n*=18): RFA of MB of cervical facet done at 80°C for 90 s<br>Litigation group (*n*=28): RFA of MB of cervical facet at same RF settings | Present in both groups | Persisted in both groups | Cervical MB RFN is effective for the treatment of cervical facet pain |
| Lord *et al*., 1996[17]*** (*n*=24) | RFN group (*n*=12): 2-3 lesions at 80°C for 90 s each<br>Control group (*n*=12) | Present in RFN group | Present in RFN group | RFN of MB is an efficacious modality for cervical facet-joint pain |

**Medium quality studies; *** High-quality studies. IA: Intra-articular; MB: Medial branch; RF: Radiofrequency; PRF: Pulsed RF; RFN: Radiofrequency neurotomy; RFA: RF ablation

operator expertise, and preference; hence, it is very difficult to formulate evidence for a therapeutic modality like RF, with so many variables capable of affecting the treatment efficacy.

A total of 286 studies have been identified after literature search and assessed for inclusion in this review. Forty-two of these studies meeting the inclusion criteria have been included for the formulation of evidence; 26 of these studies were of high quality, 14 were of moderate quality and 2 were of low quality as per Cochrane review criteria score [Table 2].

Two low-quality observational retrospective studies[18,19] were included for thoracic facet RF lesioning, where we could find only one RCT available in the literature. 22 of the 42 studies included in this review are related to facet joint pain [Tables 4-6], 7 studies for SIJ pain [Table 7], 7 studies for discogenic pain [Table 8], and 6 studies for DRG lesioning [Table 9].

The level of evidence for RF lesioning of conditions giving rise to nonradicular pain is Level I for CRF lesioning of

**Table 11: Efficacy of trials of thoracic facet joint radiofrequency lesioning**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| Gungor and Candan 2020[18]* (*n*=23) | CoRF neurotomy of thoracic MB (60°C for 150 s)<br>No control group | Present significantly | Present significantly | Conventional RFA is an effective treatment modality for thoracic facet pain |
| Rohof and Chen 2018[19]* (*n*=71) | Bipolar RFN of thoracic MB (one lesion at each level at 60°C for 150 s) | Present significantly | Present significantly | Bipolar RFN of thoracic MB is effective for thoracic facet pain |
| Joo *et al*., 2013[20]*** (*n*=40) | Group I (n=20): MBB RFA (one lesion at each level at 90°C for 90 s)<br>Group II (n=20): Dehydrated alcohol injection to MB | Present in both groups | Present in both groups<br>Prolonged effect in Group II | Alcohol ablation provides longer-lasting pain relief compared to CRF |

*Low-quality studies; *** High-quality studies. RF: Radiofrequency; CoRF: Cooled RF; CRF: Continuous RF; MB: Medial branch; MBB: MB block; RFN: Radiofrequency neurotomy; RFA: RF ablation

**Table 12: Efficacy of lumbar facet joint radiofrequency lesioning**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| McCormick *et al*., 2019[21]*** (*n*=39) | Thermal RF group: 18<br>CoRF group: 21 | Present in both groups | Present in both groups | Thermal and CoRF effective for short- and long-term |
| Song *et al*., 2019[22]** (*n*=40) | EN Group: 21<br>RFN Group: 20 | Present in both groups | Present in both groups<br>Efficacy was longer-lasting in the EN group | RN and EN Effective for short-and long-term |
| Cohen *et al*., 2018[23]*** (*n*=229) | Group I-RFA following intra-articular diagnostic block: 91<br>Group II-RFA following MBB diagnostic block: 91<br>Group III-RFA following placebo diagnostic block: 47 | Efficacy (positive responders) at 3 months: Group I (51%); Group II (56%); Group III (24%) | Efficacy (positive responders) at 6 months: Group I (31%); Group II (42%); Group III (17%) | Efficacy of RFA was found better following diagnostic blocks |
| Do *et al*., 2017[24]*** (*n*=60) | IA PRF group: 30<br>ICI group: 30 | Present in both groups | Present in both groups | IA PRF was found an effective therapeutic option with short- and long-term efficacy |
| Moussa and Khedr 2016[25]*** (*n*=120) | Facet joint capsule RF group: 40<br>Medial branch RF group: 40<br>Sham group: 40 | Present in all groups | Efficacy till 1 year: In both RF facet joint capsule group and RF medial branch groups<br>Efficacy till 3 years: Only in RF facet joint capsule group | RFA targeting the facet joint capsule gives longer period of pain relief than RFA targeting the medial branch |
| van Tilburg *et al*., 2016[26]*** (*n*=60) | Thermal RF group: 30<br>Sham group: 30 | Present in RFA group at 1 month, but absent at 3 months | NA | CRF produced a very short-term effect (not >1 month) |
| Arsanious *et al*., 2016[27]*** (*n*=47) | PRF with CRF: 26<br>Thermal RF group: 21 | Combined PDRF and CRF group efficacious in reducing postprocedural pain in the first 24 h | NA | PDRF followed by thermal RF can be considered in clinical practice to reduce postprocedural pain in the first 24 h |
| Moon *et al*., 2013[28]*** (*n*=82) | Distal approach RFA: 41<br>Conventional Tunnel vision approach RFA: 41 | Present in both groups | Present in both groups | Distal approach and conventional approach RFA had similar efficacy |
| Lakemeier *et al*., 2013[29]** (*n*=50) | Medial branch RF group: 26<br>Intra-articular Steroid group: 24 | Present in both groups | Present in both groups | RF denervation is equally effective as intra-articular steroids with benefit lasting at least 6 months |
| Roy *et al*., 2012[30]*** (*n*=34) | RF with steroid group: 34<br>No control group | Efficacy present | Efficacy present | Combining RFA with steroid infiltration produced long-lasting improvement in pain and quality of life |

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**Table 12: Contd...**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| Cohen *et al*., 2010[31]** (*n*=151) | Group I-RFA following single diagnostic block: 50<br>Group II-RFA following dual diagnostic blocks: 50<br>Group 0-RFA following clinical findings alone: 51 | Present in all RF groups<br>Outcome at 1 month and denervation success at 3 months were better in Group II (dual diagnostic block) | NA | Dual diagnostic block results in the highest success rate for RF denervation |
| Kroll *et al*., 2008[32]*** (*n*=26) | PRF group: 13<br>CRF group (conventional thermal RF): 13 | Present in CRF group | NA | Short-term efficacy with only CRF |
| Nath *et al*., 2008[33]*** (*n*=40) | RF group: 20<br>Placebo group (only LA): 20 | Present in RF group | Present in RF group (6 months) | RFA is an effective treatment modality facet joint pain |
| van Wijk *et al*., 2005[34]*** (*n*=81) | RF group: 40<br>Sham group (only LA): 41 | RF and sham groups were efficacious in improving VAS | Present in RF group for VAS of back pain, leg pain, GPE | RFA of facet joint has better long-term outcomes than the sham group |
| Buijs *et al*., 2004[35]*** (*n*=33) | Voltage controlled group: 16<br>Temperature controlled group: 17 | Significantly a greater number of adequate lesions were obtained in the temperature-controlled group than the voltage-controlled group | NA | Temperature controlled setting is preferable for RF |
| Van Kleef *et al*., 1999[36]** (*n*=31) | RF group: 15<br>Control group (only LA): 16 | Present in RF group | Present in RF group | CRF is effective for short and long-term |

**Medium quality studies; *** High-quality studies. RF: Radiofrequency; CRF: Continuous RF; IA: Intra-Articular; NA: Not Applicable; PRF: Pulsed RF; RFA: RF ablation; EN: Endoscopic neurotomy; MBB: Medial branch block; ICI: IA corticosteroid injection; PDRF: Pulsed dose RF; GPE: Global perceived effect; LA: Local anesthetic; NA: Not applicable; VAS: Visual analog scale; RFN: Radiofrequency neurotomy

**Table 13: Efficacy of trials of sacroiliac joint radiofrequency lessoning**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| Dutta *et al*., 2018[37]*** (*n*=30) | Group I: IA methylprednisolone<br>Group II: PRF | Present in both groups | Present in both groups<br>Efficacy better in PRF group | PRF for SIJ pain better than IA steroid injection |
| Mehta *et al*., 2018[38]** (*n*=17) | RFN group<br>Sham group | Present in RFN group only | Improvement continued in RFN group | CRF using a strip lesioning device useful in SIJ pain |
| van Tilburg *et al*., 2016[39]*** (*n*=60) | RFN group<br>Sham group | Present in both groups | NA | No benefit of RFN in SIJ pain |
| Patel 2016[40]*** (*n*=51) | CoRF/LBN group<br>Sham group | Not included | Present in CoRF/LBN group and in cross-over group | Prolonged effect of CoRF/LBN-mediated treatment in SIJ pain |
| Zheng *et al*., 2014[41]** (*n*=155) | Group I: PSRN<br>Group II: Celecoxib treatment | Present in both groups<br>PSRN better than celecoxib | Present in both groups<br>PSRN better than celecoxib | PSRN is superior to celecoxib for SIJ pain |
| Patel *et al*., 2012[42]*** (*n*=51) | CoRF/LBN group<br>Sham group | Present in CRF/LBN group | Present in CRF/LBN group and in cross-over group | Prolonged effect of CoRF/LBN-mediated treatment in SIJ pain |
| Cohen *et al*., 2008[43]*** (*n*=28) | CRF with CoRF group<br>Placebo group | Present in CRF with CoRF group and cross-over group | Present in CRF with CoRF group | CRF with CoRF was found useful in the management of SIJ pain |

**Medium-quality studies; *** High-quality studies. RF: Radiofrequency; CRF: Continuous RF; CoRF: Cooled RF; CoRF/LBN: Cooled RF-mediated lateral branch neurotomy; IA: Intra-articular; PRF: Pulsed RF; RFN: Radiofrequency neurotomy; SIJ: Sacroiliac joint; RN: RF neurotomy; PSRN: Palisade sacroiliac joint RN

lumbar facet medial branch, for both short- and long-term effectiveness; Level II evidence for CRF lesioning of cervical facet medial branch, CRF or CoRF lesioning of SIJ and bipolar CoRF in intradiscal biacuplasty for discogenic pain, for both short- and long-term effectiveness; Level III evidence for CRF lesioning of thoracic facet medial branch. For radicular pain management, there is Level II evidence for DRG PRF lesioning, for both short- and long-term effectiveness [Table 16].

## Limitations of the review

First, there is wide heterogenicity in the studies included in the review, with respect to patient selection, the technique of RF

**Table 14: Efficacy of radiofrequency lesioning for discogenic pain**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| Desai *et al*., 2017[44]** (*n*=60) | Group I (*n*=22): IDB + CMM<br>Group II (*n*=3): CMM<br>Crossover group (*n*=25): IDB + CMM after 6 months of CMM alone | NA | Present in IDB + CMM and cross-over group | Significant role of IDB in patients with discogenic pain |
| Desai *et al*., 2016[45]** (*n*=63) | Group I (*n*=29): IDB + CMM<br>Group II (*n*=34): CMM alone | Present in both groups<br>IDB + CMM had better outcome than CMM alone | Present in both groups<br>IDB + CMM had better outcome than CMM alone | Significant role of IDB in patients with discogenic pain |
| Kapural *et al*., 2013[46]*** (*n*=59) | IDB group (*n*=29)<br>Sham group (*n*=30) | Present in IDB group | Present in IDB group | IDB is an effective modality for discogenic pain |
| Freeman *et al*., 2005[47]*** (*n*=57) | IDET group (*n*=38)<br>Sham group (*n*=19) | Not present in any group | Not present in any group | No significant benefit from IDET in patients of discogenic low back pain |
| Oh and Shim 2004[48]** (*n*=49) | RFA lesion group (*n*=26)<br>Control group (*n*=23) | Present in RFA lesion group | NA | RFA of the ramus communicans nerve is effective in discogenic pain |
| Erçelen *et al*., 2003[49]** (*n*=39) | Group A (*n*=19): RFA at 80°C for 120 s<br>Group B (*n*=18): RFA at 80°C for 360 s | Present in both groups | Not present in any group | No effect of duration of lesion on the efficiency of intradiscal RFA |
| Barendse *et al*., 2001[50]*** (*n*=28) | RF treatment group (*n*=13)<br>Control group (*n*=15) | Not present in any group | NA | Percutaneous intradiscal RFA is not effective in reducing chronic discogenic LBP |

**Medium-quality studies; *** High-quality studies. IDB: Intradiscal biacuplasty; IDET: Intradiscal electrothermal therapy; NA: Not applicable; LBP: Low back pain; RF: Radiofrequency; RFA: RF ablation; CMM: Conventional medical management

**Table 15: Efficacy of dorsal root ganglion radiofrequency lesioning (for radicular pain)**

| Study, patients | Groups | Efficacy | | Comments |
|---|---|---|---|---|
| | | Short-term (<6 months) | Long-term (≥6 months) | |
| De *et al*., 2020[51]*** (*n*=50) | Transforaminal LA group: *n*=25<br>DRG LPRF group: *n*=25 | Present for LPRF group | Present for LPRF group | PRF of lumbosacral DRG applied for longer duration (180 s) with transforaminal LA can result in significant long-term improvement in pain and function |
| Lee *et al*., 2018[52]** (*n*=60) | DRG diagnostic block followed by PRF: *n*=30<br>DRG PRF based on clinical findings only: *n*=30 | Present for both groups | Present for both groups | Proceeding to PRF of lumbosacral DRG based on clinical findings, without a diagnostic block is more cost-effective and less invasive |
| Simopoulos *et al*., 2008[53]** (*n*=76) | PRF lesioning group: *n*=37<br>PRF and CRF lesioning group: *n*=39 | Present in both groups | Absent in both groups | PRF of DRG produces significant short-term benefit in lumbar radicular pain patients; but the addition of CRF to PRF will not result in any added benefits |
| Van Zundert *et al*., 2007[54]*** (*n*=23) | PRF group: *n*=11<br>Sham group: *n*=12 | Present in PRF DRG group | Present in PRF group for reduced analgesic consumption (not for VAS/GPE/QOL) | PRF of DRG is an effective modality for the treatment of cervical radicular pan |
| Geurts *et al*., 2003[55]*** (*n*=83) | RF group: *n*=45<br>Control group: *n*=38 | Absent for RF group | Absent for RF group | RF lesioning of DRG failed to show any significant benefit in patients with lumbosacral radicular pain |
| Slappendel *et al*., 1997[56]*** (*n*=61) | CRF lesioning at 67°C: *n*=32<br>CRF lesioning at 40°C: *n*=29 | Present for both groups | NA | RF lesioning of cervical DRG at 67°C as well as 40°C are equally effective for the treatment of cervical radicular pain |

**Medium-quality studies; *** High-quality studies. RF: Radiofrequency; CRF: Continuous RF; GPE: Global perceived effect; LA: Local anesthetic; LBP: Low back pain; LPRF: Lumbar pulsed RF; NA: Not applicable; PRF: Pulsed RF; QOL: Quality of life; RFA: RF ablation; VAS: Visual analog scale; DRG: Dorsal root ganglion

**Table 16: Level of evidence of radiofrequency lesioning for chronic spinal pain**

| | Level of evidence | Literature suggestive of evidence |
|---|---|---|
| Facet joint pain | | |
| Cervical facet | Level II for CRF lesioning of MB | 1 high-quality RCT[17] and 2 medium quality studies[15,6] |
| Thoracic facet | Level III for CRF lesioning of MB | 1 high-quality RCT[20] |
| Lumbar facet | Level I for CRF lesioning of MB | 8 high quality studies[21,24,25,27,28,32-34] and 1 moderate quality study[22] |
| SIJ pain | Level II for CRF lesioning | 2 moderate quality RCTs and one high-quality RCT[38,41,43] |
| | Level II for CoRF lesioning | 2 high quality RCTs[40,42] |
| Discogenic pain | Level II for bipolar CoRF in intradiscal biacuplasty | 1 high-quality RCT[46] and 1 moderate quality RCT[44] |
| DRG lesioning for Radicular pain | Level II for PRF lesioning | 1 high-quality RCT[51] and 1 moderate quality RCT[52] |

**Medium-quality studies; *** High-quality studies. CRF: Continuous radiofrequency; CoRF: Cooled radiofrequency; DRG: Doral root ganglion; PRF: Pulsed radiofrequency; RCTs: Randomized controlled trials; SIJ: Sacroiliac joint; MB: Medial branch

lesioning employed, and outcome measures studied. Secondly, we have included RCTs with a minimum follow-up period of 3 months; this kind of study selection was done due to the paucity of good quality RF lesioning studies in many chronic spinal pain conditions. Hence, systematic reviews in future, can arrive in a better conclusion regarding the efficacy of RF, if more RCTs with a large sample size and long follow-up period are available. Thirdly, we have done literature search for the role of RF lesioning for various conditions; however, in certain conditions more than one RF type has been used in different trials (for example SIJ pain, discogenic pain, and DRG lesioning). A literature search focusing on specific RF types will result in the inclusion of more observational trials owing to the lack of adequate RCTs focusing on specific RF types; this carries a possibility of affecting the overall evidence.

## Conclusion

The evidence for RF lesioning of chronic spinal pain is summarized as follows:

1. Nonradicular pain:
    a. Cervical facet joint pain: Level II evidence for CRF lesioning of cervical facet medial branch (short- and long-term effectiveness); the CRF lesioning parameters advised for cervical facet medial branch are 80°–85° C for 90 s.[15-17]
    b. Thoracic facet joint pain: Level III evidence for CRF lesioning of thoracic facet medial branch (short- and long-term effectiveness); the CRF lesioning parameters advised for thoracic facet medial branch are 90°C for 90 s.[20]
    c. Lumbar facet joint pain: Level I evidence for CRF lesioning of lumbar facet medial branch (short-and long-term effectiveness); the CRF lesioning parameters advised for lumbar facet medial branch are 80°C for 90 s.[21,22,25,27-31]
    d. Sacro-iliac joint pain: Level II for CRF or CoRF lesioning of SIJ (short- and long-term effectiveness); RF lesioning parameters advised are 80°-90°C for 90–180 s for CRF[41,43] and 60°C for 150 s for CoRF.[40,42,43]
    e. Discogenic pain: Level II evidence for bipolar CoRF in intradiscal biacuplasty for discogenic pain (short-and long-term effectiveness).[44-46]
2. Radicular pain: Level II evidence for DRG PRF lesioning for the management of radicular pain; the PRF lesioning parameters used for DRG medial branch for the management of radicular pain are 42°C for 120–180 s.[51-54]

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## Conflicts of interest

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