Review Article

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Interventional Minimally Invasive Treatments for Chronic Low Back Pain Caused by Lumbar Facet Joint Syndrome: A Systematic Review

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Abstract

Study design: Systematic review.

Objective: To investigate the efficacy of nonsurgical interventional treatments for chronic low back pain (LBP) caused by facet joint syndrome (FJS).

Methods: A systematic review of the literature was conducted to identify studies that compared interventional treatments for LBP due to FJS among them, with usual care or sham procedures. Studies were evaluated for pain, physical function, disability, quality of life and employment status. The RoB-2 and MINORS tools were utilized to assess the risk of bias in included studies.

Results: Eighteen studies published between January 2000 and December 2021 were included (1496 patients, mean age: 54.31 years old). Intraarticular (IA) facet joint (FJ) injection of hyaluronic acid (HA) did not show significant difference compared to IA corticosteroids (CCS) in terms of pain and satisfaction. FJ denervation using radiofrequency (RF) displayed slightly superior or similar outcomes compared to IA CCS, physical therapy, or sham procedure. IA CCS showed better outcomes when combined with oral diclofenac compared to IA CCS or oral diclofenac alone but was not superior to IA local anesthetic and Sarapin. IA platelet-rich plasma (PRP) led to an improvement of pain, disability and satisfaction in the long term compared to IA CCS.

Conclusion: FJS is a common cause of LBP that can be managed with several different strategies, including nonsurgical minimally invasive approaches such as IA HA, CCS, PRP and FJ denervation. However, available evidence showed mixed results, with overall little short-term or no benefits on pain, disability, and other investigated outcomes.

Keywords

low back pain, facet joint, radiofrequency, corticosteroids, denervation, hyaluronic acid

Introduction

Low back pain (LBP) represents a worldwide burden with significant epidemiological, social, and economic resonance. Indeed, it is considered among the most common musculoskeletal conditions globally[1] and the leading cause of years lived with disability[2-4].

Spinal causes of LBP include myofascial pain, intervertebral disc degeneration, spinal stenosis, sacroiliac joint pain,

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and facet joint syndrome (FJS)[5-9]. Other causes include tumors, infections, deformities, neuropathic pain, inflammatory conditions (such as ankylosing spondylitis and rheumatoid arthritis) and non-spinal causes (including visceral causes as well as mood disorders). The literature has been widely focused on intervertebral discs as the source of LBP; however, facet joints (FJ) also play a major role in generating LBP.

FJS is characterized by wear and tear of joint surfaces due to degenerative processes, spondylolisthesis, septic arthritis, and systemic inflammatory phenomena. FJ osteoarthritis is the most common facet pathology. This syndrome appears to be the cause of 10-15% of chronic LBP cases in the young adult population and at even higher rates in the elderly.[10] The diagnosis of chronic LBP related to FJS involves several steps, from physical examination to provocative maneuvers together with imaging,[11] even though the correlation between clinical symptoms and degenerative spinal changes is still unclear.[12] Indeed, these examinations do not provide diagnostic certainty. A FJ nerve block with a local anesthetic can support the identification of FJs as the source of chronic LBP.[13]

The first-line treatment comprises a multimodal approach involving medications (acetaminophen, non-steroidal anti-inflammatory drugs, muscle relaxants and antidepressants), physiotherapy and eventually psychotherapy.[14,15] When conservative treatment is not sufficient, patients may benefit from local or intraarticular (IA) injections (using corticosteroids – CCS – and/or local anesthetics, hyaluronic acid – HA - or platelet-rich plasma – PRP -), prolotherapy (e.g., injection of a solution not containing biologic material with the goal of improving pain using dextrose or phenol) or physical (pulsed or conventional radiofrequency, cryoneurolysis) denervation techniques to eliminate FJ pain.[16] Surgical management including lumbar facet joint replacement is still controversial.[17,18] Spinal fusion and decompression can be indicated as a last resort in patients with symptoms refractory to nonoperative modalities or in advanced stages with associated synovial facet cyst causing radiculopathy and/or spinal stenosis.[19]

The aim of the present study was to systematically review the literature to investigate the efficacy of minimally invasive interventional procedures routinely used for the clinical management of LBP related to FJS. While previous studies have been mainly focused on a specific subset of nonsurgical interventions for FJS (e.g., FJ nerve block, rafiofrequency denervation, see below), this report offers a wide perspective on available therapeutic strategies to tackle LBP due to FJS, with the objective of providing evidence-based guidance to treatments that have been described in the literature so far.

Materials and Methods

The methods for this systematic review followed accepted standards for systematic review/comparative effectiveness reviews for rigor, quality, and transparency including those described by the Agency for Healthcare Research and Quality (AHRQ),[20] IOM Standards for Systematic Reviews,[21] and the PCORI Methods Guide.[22]

Electronic Literature Search

A systematic search of PubMed/MEDLINE, Scopus, CINAHL, EMBASE, CENTRAL, and Cochrane databases was performed for literature published through January 2000 and December 1, 2021. Briefly, we sought to identify comparative studies investigating the effect of minimally invasive interventional procedures for treating LBP due to FJS. The research question was formulated using a PICOS-approach: Patient (P); Intervention (I); Comparison (C); Outcome (O) and Study design (S). The aim of this systematic review was to select those articles which described "if adult patients with LBP due to FJS (P) treated by nonsurgical minimally invasive interventional procedures (I) have better results in terms of clinical outcomes and complications (O) when treated with other approaches already in use (C)". For this purpose, only randomized control trials (RCTs), cohort studies (CS), prospective (PS) or retrospective (RS) studies with ≥ 10 patients per group were included. Only studies on humans with abstracts written in English were considered, with no other limits placed on the search. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were used to improve the reporting of the review as described by Moher et al.[23] For the search strategy, the following key words were used: "low back pain", "zygapophyseal joint", "facet joint", "syndrome", "denervation", "neurolysis", "ablation", "radiofrequency", "nerve block", "steroid", "injections". The keywords were used isolated or combined. The complete search strategy with the Medline string is reported as Supplementary File 1. Eventually, additional studies among the reference lists of the selected papers and systematic reviews were searched and included upon adherence with the search criteria.

Study Selection

The initial search of the article was performed by three reviewers (L.A., A.R. and M.D.F). In case of disagreements, the consensus of a third reviewer (G.P.) was asked. The research was conducted using the CADIMA software.[24] The following research order was used: titles were screened first, then abstracts and full papers. A paper was considered potentially relevant and its full text reviewed if, following a discussion between the two independent reviewers, it could not be unequivocally excluded on the basis of its title and abstract. The full text of all papers not excluded based on abstract or title was subsequently evaluated. The number of articles excluded or included were recorded and reported in a PRISMA flowchart (Figure 1).

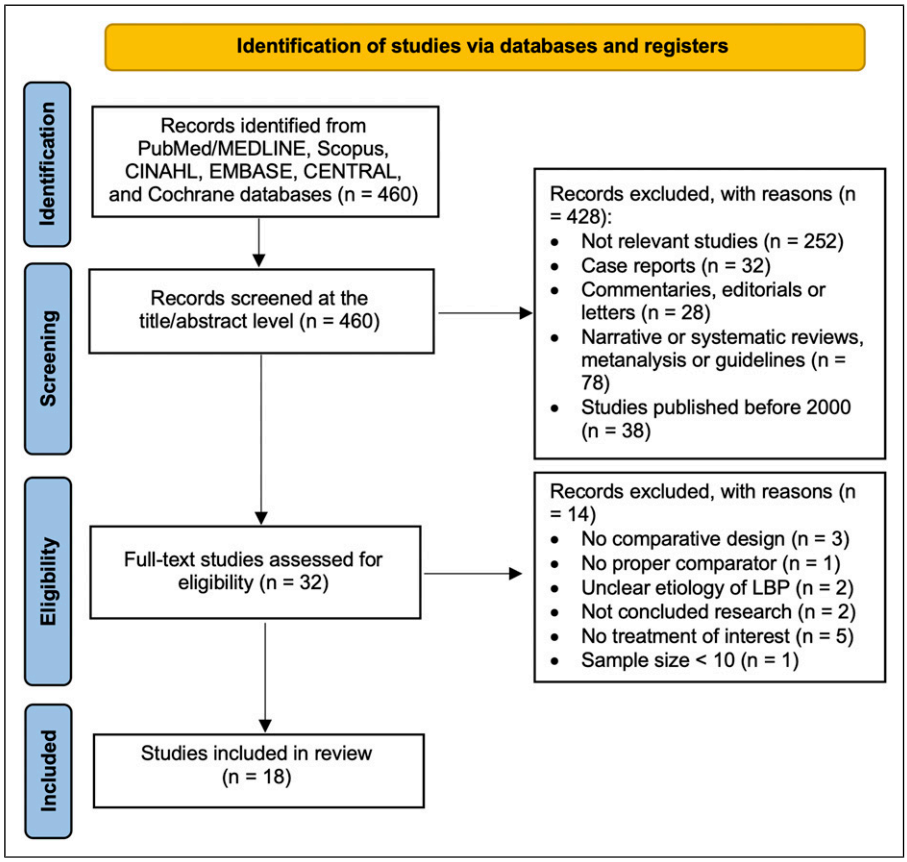

Figure 1. Search strategy flow diagram in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol.

Data Extraction

General study characteristics extracted were: authors, country, sample size, mean age, mean follow-up, study design, level of evidence (LOE), year of publication, intervention and comparison procedures, interventional techniques, and patient-reported outcomes (PROs) including Visual Analogue Scale (VAS), Numeric Rating Scale (NRS), Patient Disability Questionnaire (PDQ), Odom's criteria, North American Spine Society (NASS) patient satisfaction questionnaire, European Quality of Life 5 Dimensions (EQ-5D) questionnaire, Global Perceived Effect (GPE) scale, Oswestry Disabiliy Index (ODI), Roland-Morris Questionnaire (RMQ), RAND 36-Item Health Survey, World Health Organization (WHO) analgesics intake score, and West Haven-Yale Multidimensional Pain Inventory (MPI). In addition, complications and conclusions of the studies were reported.

Risk of Bias

Given the observational design of included studies, the Risk of Bias 2 tool (RoB-2)[25] for RCTs and the Methodological Index for Non-Randomized Studies (MINORS)[26] tool for non-randomized RCTs (NRCTs) were utilized to assess the risk of bias. In order to avoid imprecisions, selected papers were rated independently by two reviewers (F.R. and L.A.) and verified by a third one (G.P.). The "Robvis" tool was utilized to generate the traffic light plot in accordance with Cochrane recommendations.

Results

Study Selection

A total of 460 studies were found. Of these studies, 428 articles were excluded through title and abstract screening. Then, 32 full-text articles were screened. Out of these studies, 14 were excluded (no proper comparator, n = 1; unclear etiology of LBP, n = 2; intervention treatments inappropriate for the review question, n = 5; unconcluded research, n = 2; sample size < 10, n = 1, no comparative design, n = 3). After this process, 18 articles were included in our study. The review protocol has been approved by the International prospective register of systematic reviews (PROSPERO) under the ID CRD42022343162. The high heterogeneity between studies (in terms of type of intervention and comparison technique as

Table 1. Study Design and Patient Demographics of Included Studies.

Study	Country	Sample size (n)		Mean age (years)		Mean follow-up (months)		Study design	LOE
		Intervention	Comparison	Intervention	Comparison	Intervention	Comparison		
Annaswami 2018[27]	USA	12	13	58.9 ± 7.9	57.7 ± 6.2	6	6	RCT	II
Cetin 2018[28]	Turkey	43	75	53.90 ± 16.23	53.39 ± 16.14	24	24	RCT	II
Civelek 2012[29]	Turkey	50	50	51.8 ± 17	56.5 ± 17.7	12	12	RCT	II
Do 2017[39]	South Korea	30	30	66.9 ± 9.6	63 ± 10.9	6	6	RCT	II
Juch 2017[40]	Canada	125	126	52.98 ± 11.98	52.60 ± 10.79	12	12	RCT	II
Kennedy 2018[41]	USA	14	14	61.9	64.4	12	12	RCT	II
Kroll 2008 [30]	USA	13	13	57.0 ± 8.4	59.5 ± 11.6	3	3	RCT	II
Lakemeier 2013[31]	Germany	26	24	57.6 ± 12.8	56.3 ± 10.8	6	6	RCT	II
Leclaire 2001[32]	France	36	34	46.7 ± 9.3	46.4 ± 9.8	3	3	RCT	II
Manchikanti 2001[44]	USA	41	32	47.2 ± 2.69	46.3 ± 2.86	30	30	RCT	II
Manchikanti 2010[42]	USA	60	60	46 ± 17	48 ± 15	24	24	RCT	II
Moussa 2020[33]	Egypt	100	50	57.3; 56.7	56.9	36	36	RCT	II
Nath 2008[34]	Sweden	20	20	56	53	6	6	RCT	II
Sae-Jung 2016[35]	Thailand	32; 34	33	44 ± 9.3; 46 ± 9.2	49 ± 8.7	3	3	RCT	II
van Tilburg 2016[43]	Netherlands	30	30	65	58	3	3	RCT	II
Wu 2017[38]	China	23	23	52.91 ± 7.6	52.78 ± 7.25	6	6	RCT	II
Yasar 2018[36]	Turkey	50	50	47.4 ± 11.1	43.1 ± 8.5	12	12	PS	II
Zhou 2016[37]	China	40	40	56.5 ± 8.7	54.6 ± 7.5	6	6	RCT	II

Abbreviations:IA, intraarticular; CCS ,corticosteroids; CRF, continuous radiofrequency; DRG, dorsal root ganglion; HA, hyaluronic acid; MDB, medial dorsal branch; PRF, pulsed radiofrequency; PS, prospective study; PT, physical therapy, RCT, randomized controlled trial; RF, radiofrequency.

well as outcomes) precluded an effective meta-analysis from being conducted.

Study Characteristics

Selected studies included 17 RCTs, LOE II and 1 NRCT (1 PS, LOE II). Studies were published between 2001 and 2020. A total of 1496 patients (717 in the comparison group vs 779 in the intervention group) with a mean age of 54.31 years old were assessed for outcomes following minimally invasive interventional procedures for FJS. Of these studies, 5 were performed in USA, 3 in Turkey, 1 was performed in South Korea, 1 in Canada, 1 in Germany, 1 in France, 1 in Egypt, 1 in Sweden, 1 in Thailand, 2 in China and 1 in Netherlands. Follow-up ranged from 3 months to 36 months (Table 1). Pain evaluation in these studies was performed using the VAS scale (12 studies[27-38]), the NRS scale (5 studies[39-43]), an unspecified verbal scale (1 study[44]) and the MPI (1 study[40]). The disability outcome was evaluated by one or more of the following scales: ODI (10 studies[30-33,35,36,38,40-42]), RMQ (3 studies[31,32,38]) and an unspecified scale (1 study[44]). Patient satisfaction was evaluated by Odom's criteria (1 study[28]), NASS questionnaire (1 study[29]), EQ-5D (2 studies[29,40]), modified MacNab criteria (1 study[38]) and GPE scale (3 studies[33,40,43]). General health was assessed with the RAND-36 scale (1 study[40]) and with an unspecified scale (2 studies[34,44]). Employment status was reported in 3 studies.[32,42,44] Analgesic intake was evaluated with the WHO analgesics intake score (1 study[33]), an unspecified scale (1 study[34]) or simply described (3 studies[38,42,44]). Lumbar stiffness was evaluated with the Schober's test in 1 study.[37] The efficacy of treatment was evaluated using the Surgical Efficacy Criteria of the Spine Surgery Group, Orthopedic Branch of Chinese Medical Association in 1 study.[37]

Risk of Bias

The RoB-2 tool for RCTs and the MINORS score for NRCTs, were used to assess the risk of bias of each study. For RCTs, we found 5 studies with an overall risk of bias identified as "low", 7 as "some concerns" and 5 as "high risk" (Figure 2). The MINORS tool was adopted to assess the quality of

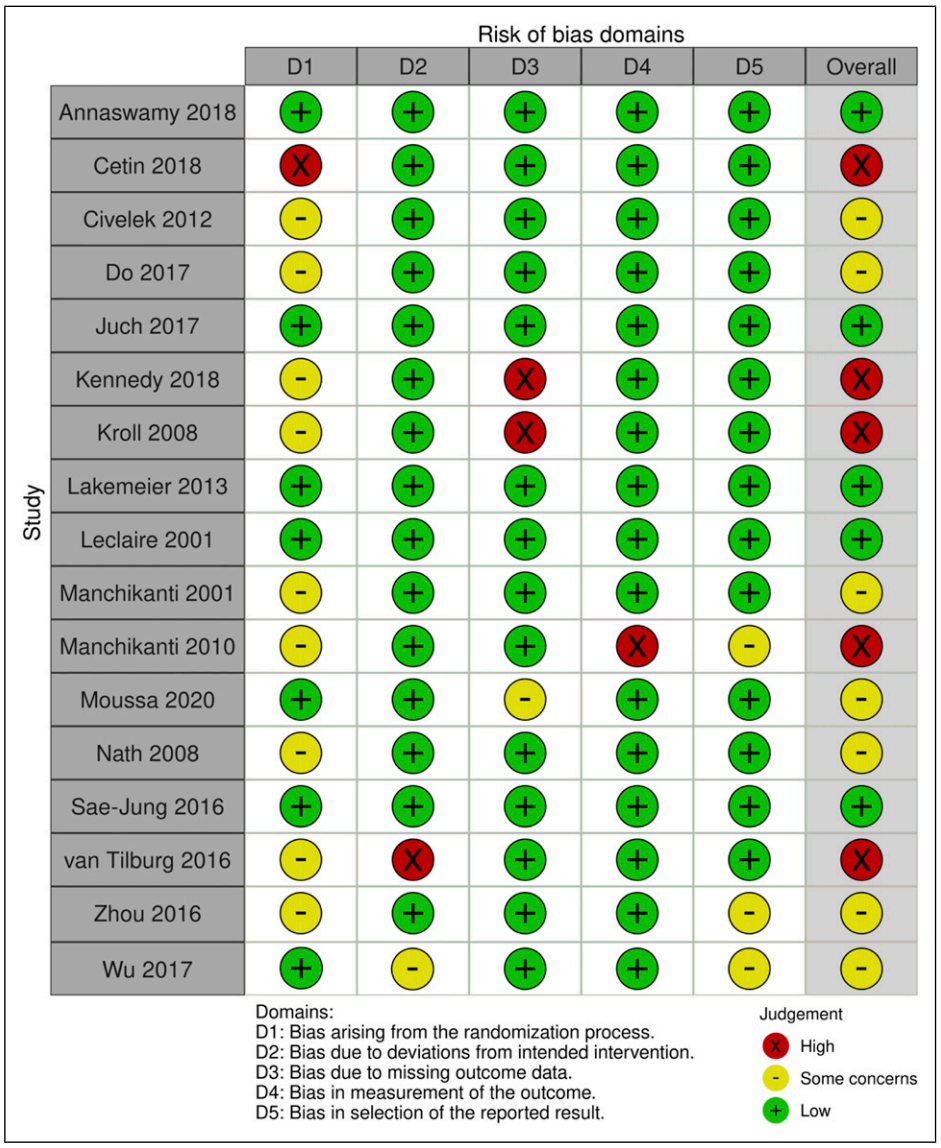

Figure 2. Risk of bias as assessed by the Risk of Bias of Randomized Controlled Trials (RoB 2) tool based on the Cochrane Handbook for Systematic Reviews of Intervention.

evidence of the only included NRCT, with a total score of 18/24 (Supplementary Table).

Results of Individual Studies

Intervention procedures with their corresponding comparators, as well as investigated outcomes and complications, are depicted in Tables 2 and 3, respectively.

IA HA. The study by Annaswamy et al.[27] evaluated the effect of IA hyaluronic acid (8 mg Hylan GF-10) compared to IA CCS (1 ml of 10 mg/ml triamcinolone). No significant intergroup differences in terms of VAS, PDQ and overall satisfaction at 6 months, both before and after the treatment, were reported. Regarding within-group analyses, the only statistically significant change noted was in the HA group, which showed an improvement of VAS only at the 1 month-time point compared to baseline (70 ± 20 vs 45 ± 25, $P = .008$). Regarding PDQ scores, patients in the CCS group showed a statistically significant improvement only at 1 month (100 ± 23 vs 77 ± 30, $P = .009$) whereas patients in the HA group showed significant improvements from baseline (102 ± 28) at all time points: 1 month (74 ± 34, $P = .002$), 3 months (74 ± 36, $P = .037$) and 6 months (52-99.5, $P < .001$). Failed injection was reported in 3/13 patients in the CCS group and 1/12 patients in the HA group, while 3/13 and 2/12 reported a

Table 2. Intervention Characteristics of Included Studies.

Study	Intervention group	Intervention group technique	Comparison group	Comparison group technique
Annaswami 2018[27]	IA HA	Under fluoroscopic guidance, 1 ml of Synvisc-One® (8 mg of Hylan GF-10 in each joint (bilateral L3-4, L4-5 and L5-S1).	IA CCS	Under fluoroscopic guidance, 1 ml of triamcinolone (10 mg/ml) in each joint (bilateral L3-4, L4-5 and L5-S1).
Cetin 2018[28]	PRF	The RF lesion generator was set up as PRF, 2 Hz frequency at 42°C with pulse waves at 20 ms width and was applied for 3 minutes. At the end of the RF procedure, 2 mg methylprednisolone was given for each level.	CRF	RF neurolysis was performed by applying 80°C CRF for 90 seconds. At the end of the RF procedure, 2 mg methylprednisolone was given for each level.
Civelek 2012[29]	CRF	Under fluoroscopic guidance, the RF electrode was advanced until reaching the desired location. Following sensory and motor testing, a 5-mm active tip electrode was used to create a single lesion at 80°C for 120 s. No post RF injection of steroids or local anesthetics was performed.	IA CCS	Under fluoroscopic guidance, the trajectory to the FJ was chosen. After application of local anesthetic (lidocaine, 1% mixed with bicarbonate), the needle was inserted and advanced to the FJ. 40 mg methylprednisolone acetate (1 mL volume) mixed with 1.5-2 mL bupivacaine (.25%-.5%) were then injected.
Do 2017[39]	PRF	Under fluoroscopic guidance, PRF treatment was administered at 5 Hz, and a 5 ms pulsed width, for 360 s, at 55 V, with the electrode tip temperature not exceeding 42°C.	IA CCS	Under C-arm fluoroscopy, after confirming IA access by injecting .3 mL of contrast into the facet joint space, 10 mg (.25 mL) of dexamethasone mixed with .25 mL of .125% bupivacaine were injected.
Juch 2017[40]	CRF + PT	Under fluoroscopic guidance, following sensory and motor testing, once the position of the electrode was satisfactory, 1-2 ml per level ml 2% lidocaine was injected and a 90°C – 90 s RF lesion was made at the MDB of L3-4, L4-5, and L5-S1.	PT	Patients followed an 8 – to 12-hour PT program focused on quality of movement and behavior which took place during a 3-month intervention period.
Kennedy 2018[41]	IA CCS	Under fluoroscopic guidance, .5 mL of triamcinolone 40 mg/mL were injected at each joint identified through an initial diagnostic block.	IA saline	Under fluoroscopic guidance, .5 mL of saline were injected at each joint identified through an initial diagnostic block.
Kroll 2008[30]	PRF	Under fluoroscopic guidance, following provocative testing, 1 mL of .5% bupivacaine was injected and then PRF was delivered at 42°C with a pulse duration of 20 ms and pulse rate of 2 Hz for 120 s.	CRF	Under fluoroscopic guidance, following provocative testing, 1 mL of .5% bupivacaine was injected and then CRF thermocoagulation was performed at 80°C for 75 s.
Lakemeier 2013[31]	CRF	Under fluoroscopic guidance, following sensory and motor testing, 1 mL of .5% bupivacaine was injected, and RF was administered at 80°C for 90 s.	IA CCS	Under fluoroscopic guidance, a mixture of .5 mL of .5% bupivacaine and 1 mL of betamethasone (3 mg) was injected into the target joint.
Leclaire 2001[32]	CRF	Under fluoroscopic guidance, following provocative testing, 2 mL of 1% lidocaine were injected and RF was delivered at a temperature of 80°C for 90 s. For each nerve, two neurotomies were performed, one at the proximal portion and another at the distal portion of the facet joint nerve.	Sham procedure	The patients in the control group received the same procedure, except that the temperature of the electrode tip was maintained at 37°C.

(continued)

Table 2. (continued)

Study	Intervention group	Intervention group technique	Comparison group	Comparison group technique
Manchikanti 2001[44]	IA local anesthetic + Sarapin + CCS	Under fluoroscopic guidance, each nerve was infiltrated with .5 to 1 mL of a mixture of local anesthetic consisting of either .5% lidocaine or .25% bupivacaine mixed with equal volumes of Sarapin and 1 mg of methylprednisolone/mL of the mixture.	IA local anesthetic + Sarapin	The patients in the control group received the same procedure, but no CCS was used.
Manchikanti 2010[42]	IA local anesthetic + CCS ± Sarapin	Under fluoroscopic guidance, each level was injected with a .5 to 1.5 mL mixture including .15 mg/mL betamethasone and bupivacaine ± Sarapin.	IA local anesthetic ± Sarapin	Under fluoroscopic guidance, each level was injected with a .5 to 1.5 mL mixture including bupivacaine ± Sarapin.
Moussa 2020[33]	DRG/MDB PRF	Under fluoroscopic guidance, following sensory and motor testing, once the position of the electrode was approaching the DRG, 4 cycles of PRF stimulation were used: each cycle lasted for 2 min using 2 Hz stimulation at 45 V with at the cannula's tip temperature not exceeding 42 °C. For the facet joints, 3 lesions were created at a temperature of 85°C for 90 s each along the course of the MDB separated by 2 mm interval between each lesion to increase the chance of effective denervation. 1 cc of a mixture of equal volume of bupivacaine .5 % and methylprednisolone acetate 40 mg/mL were injected at the conclusion of the procedure.	Sham procedure	Patients in the control (sham) group were submitted to the same electrode set-up with the RF generator switched on but without delivering current to the thermocouple electrode. 1 cc of a mixture of equal volume of bupivacaine .5 % and methylprednisolone acetate 40 mg/mL were injected at the conclusion of the procedure.
Nath 2008[34]	CRF	Under fluoroscopic guidance, the thermistor probe was inserted, and a 60 s-lesion was performed maintaining a temperature of 85°C. The cannula was then withdrawn 5 mm and another lesion made. To accommodate possible variations in location of the target nerve, 4 more lesions were performed just lateral and just medial to the first 2 lesions.	Sham procedure	The patients in the control group received the same procedure, except that the temperature of the electrode tip was maintained at body temperature.
Sae-Jung 2016[35]	IA CCS + oral diclofenac	Under fluoroscopic guidance, 80 mg methylprednisolone acetate combined with 1 ml of .5 % bupivacaine were injected in each symptomatic facet joint. In addition, patients took 50 mg oral diclofenac twice daily for 2 weeks.	IA CCS alone or oral diclofenac alone	Under fluoroscopic guidance, 80 mg methylprednisolone acetate combined with 1 ml of .5 % bupivacaine were injected in each symptomatic facet joint. The oral diclofenac group received two weeks of 50 mg oral diclofenac taken twice daily.
Van Tilburg 2016[43]	CRF	Under fluoroscopic guidance, following sensory and motor testing, .5 mL lidocaine 2% was introduced around each medial branch, an RF heat lesion (80°C for 60 s per level was given).	Sham procedure	The patients in the control group received the same procedure, without performing any RF lesions.
Wu 2017[38]	PRP	Following a confirmatory diagnostic block, selected facets were injected with .5 mL autologous PRP under fluoroscopic guidance.	IA CCS + local anesthetic	Following a confirmatory diagnostic block, selected facets were injected with .5 mL .5% lidocaine and 5 mg/mL betamethasone (4:1, vol/vol) under fluoroscopic guidance.

(continued)

Table 2. (continued)

Study	Intervention group	Intervention group technique	Comparison group	Comparison group technique
Yasar 2018[36]	PRF	Under fluoroscopic guidance, following sensory and motor testing, PRF was administered at 42°C in 120 s (2 shots of 45 V/s).	IA CCS	Under fluoroscopic guidance, 2.5 mL mixture of .25% bupivacaine and 40 mg of methylprednisolone acetate were injected into each level.
Zhou 2016[37]	CRF	Under fluoroscopic guidance, following sensory and motor testing, approximately .3 mL of 2% lidocaine was injected and 80°C RF was performed for 90 s.	IA CCS	Under fluoroscopic guidance, the patients were injected with 5 mL of mixed solution containing 1 mL of betamethasone and 1 mL of 2% lidocaine (diluted with normal saline) into the cavity of the facet joint, around the MDB and the facet joint.

Abbreviations: IA, intraarticular; CCS, corticosteroids; CRF, continuous radiofrequency; DRG, dorsal root ganglion; HA, hyaluronic acid; MDB, medial dorsal branch; PRF, pulsed radiofrequency; PRP, platelet-rich plasma; PT, physical therapy, RF, radiofrequency.

transient LBP increase in the former and latter groups, respectively.

RF FJ Denervation. The efficacy of pulsed radiofrequency (PRF) compared to continuous radiofrequency (CRF) facet joint denervation was assessed in 2 studies.[28,30]

Cetin et al.[28] demonstrated that both PRF and CRF decreased VAS score compared to baseline (8.44 ± .93 and 8.10 ± .95, respectively). However, CRF was associated with lower pain scores compared to PRF at 1 month (CRF: 3.27 ± 1.24; PRF: 3.79 ± 1.05, $P = .027$), 3 months (CRF: 3.39 ± 1.04; PRF: 4.09 ± 1.11, $P = .001$) and 6 months (CRF 3.79 ± .67; PRF: 5.66 ± 1.14:, $P = .001$), while VAS scores were higher in the CRF group at 1 year (CRF: 4.04 ± .81; PRF: 3.69 ± .86, $P = .001$) and 2 years (CRF: 4.09 ± .78; PRF: 5.20 ± 1.06, $P = .001$). In terms of satisfaction, the Odom's criteria reported excellent/good outcomes in 38/43 patients in the CRF group and 8/75 patients in the PRF group, while fair/poor results were reported in 4/43 and 67/75 patients treated with CRF and PRF, respectively. Furthermore, neuropathic pain developed in 1 patient within the CRF group and 2 patients within the PRF group.

Conversely, Kroll et al.[30] reported no significant intergroup differences in terms of pain and disability before and after the treatments. Within the CRF group, a significant improvement of VAS and ODI scores were found at 3 months compared to baseline (51.9 ± 27.4 vs 76.2 ± 16 and 41.7 ± 16.9 vs 52 ± 17.3, respectively), while no difference was retrieved in the PRF group.The efficacy of RF compared to locally injected CCS was assessed in 5 studies.[29,31,36,37,39]

In the study from Civelek et al.[29], both groups showed a significant improvement of mean VAS scores vs the baseline (CCS: 8.5; CRF: 8.2) at all timepoints. While VAS was lower in the CCS group soon after the procedure (CCS: 1.2; CRF: 2.4, $P = .00$), pain scores were significantly decreased in the CRF group at 1 month (CCS: 3.4; CRF: 2.2, $P = .00$), 6 months (CCS: 4.4; CRF: 2.5, $P = .00$) and 12 months (CCS: 4.9; CRF: 2.6, $P = .00$). Conversely, no significant intergroup difference was found in terms of EQ-5D and NASS scores, except for the latter at 12 months (CCS: 2; CRF: 1.5, $P = .04$). Burning-like dysesthesias were reported in 2 patients in the CRF group.

Lakemeier et al.[31] reported that, while both groups showed an improvement of VAS, RMQ and ODI following the procedure, no significant intergroup difference in any score was reported at the 6-month follow-up.

Yasar et al.[36] found that VAS scores decreased compared to baseline in both groups (CCS: 6.4 ± .9; PRF: 5.8 ± 1) and were significantly lower in the PRF group at 3 months (CCS: 3.3 ± 1; PRF: 2.5 ± 1, $P < .05$) and 6 months (CCS: 3.3 ± .9; PRF: 2.3 ± 1.4, $P < .05$). However, no statistically significant difference was found at 9 months (CCS: 2.5 ± 1; PRF: 2.7 ± .9) and 12 months (CCS: 3 ± 1.5; PRF: 3 ± 1.1). Similarly, ODI improved from preoperative (CCS: 57.2 ± 13.9; PRF: 58.5 ± 13.1) and was significantly lower in the PRF group at 3 (CCS: 24.1 ± 8.7; PRF: 18.9 ± 5.7, $P < .05$) and 6 months (CCS: 24.8 ± 9.5; PRF: 14.9 ± 7, $P < .05$), while scores were comparable at subsequent follow-ups (9 months: CCS: 12.2 ± 3.8; PRF: 10.4 ± 2.8;12 months: CCS: 12.1 ± 4.4; PRF: 17.2 ± 6.4). Post-injection pain was experienced in 4% of study participants.

Zhou et al.[37] reported that mean VAS score significantly decreased from baseline (CCS: 6.8; CRF: 6.7) in both groups, but no intergroup difference was found at 30 minutes (CCS: 3.6; PRF: 3.5), 1 day (CCS: 2.7; PRF: 2.7) and 1 week (CCS: 1.9; PRF: 1.4) following the procedure. Conversely, VAS was significantly lower in the PRF group after 1 month (CCS: 3.6; PRF: 1.4, $P < .05$) and 12 months (CCS: 5.8; PRF: 1.7, $P < .05$). With regards to the mean Schober index, no significant difference was reported compared to the baseline (CCS: 6.85 CRF: 6.6) at any timepoint and between groups at 1 week (CCS: 8.9; PRF: 9), while it was significantly higher in patients treated with PRF after 1 month (CCS: 7.3; PRF: 8.6, $P < .01$) and 12 months (CCS: 6.2; PRF: 8.8, $P < .05$). Considering the patient-reported half-year efficacy assessed with the

Table 3. Outcomes, Complications, and Conclusions of Included Studies.

Study	Outcomes	Complications	Conclusions
Annaswami 2018[27]	No significant intergroup differences in terms of VAS, PDQ and overall satisfaction at 6 months.	Failed injection attempt CCS: 3/13; HA: 1/12 Transient pain increase CCS: 3/13; HA: 2/12	No statistical intergroup differences in pain relief or functional improvement were found when comparing triamcinolone and HA injections in treating patients with chronic LBP likely caused by FJS.
Cetin 2018[28]	VAS Baseline: CRF: 8.44 ± .93; PRF: 8.10 ± .95, ns 1 month: CRF: 3.27 ± 1.24; PRF: 3.79 ± 1.05, *P* = .027 3 months: CRF: 3.39 ± 1.04; PRF: 4.09 ± 1.11, *P* = .001 6 months: CRF 3.79 ± .67; PRF: 5.66 ± 1.14:, *P* = .001 1 year: CRF: 4.04 ± .81; PRF: 3.69 ± .86, *P* = .001 2 years: CRF: 4.09 ± .78; PRF: 5.20 ± 1.06, *P* = .001 Odom's criteria (n) Excellent/good: CRF: 38/43; PRF: 8/75, *P* = .001 Fair/poor: CRF: 4/43; PRF: 67/75, *P* = .001	Development of neuropathic pain (n) CRF: 1/43, PRF = 2/75	PRF of the MDB has a shorter effect on pain relief compared to CRF in patients with FJS.
Civelek 2012[29]	VAS Baseline: CCS: 8.5; CRF: 8.2, ns Post-procedural: CCS: 1.2; CRF: 2.4 (*P* = .00) 1 month: CCS: 3.4; CRF: 2.2 (*P* = .00) 6 months: CCS: 4.4; CRF: 2.5 (*P* = .00) 12 months: CCS: 4.9; CRF: 2.6 (*P* = .00) NASS questionnaire 1 month: CCS: 1.3; CRF: 1.3 (ns) 6 months: CCS: 1.7; CRF: 1.4 (ns) 12 months: CCS: 2; CRF: 1.5 (*P* = .04) No significant intergroup differences in terms of EQ-5D.	Burning-like dysesthesias CCS: 0/50; CRF: 2/50	IA CCS should be considered the first choice in patients with FJS. In case of pain recurrence, RF can be performed.
Do 2017[39]	NRS Baseline: CCS: 5.0 ± .8; PRF: 4.9 ± .8 (ns) 2 weeks: CCS: 1.4 ± .8; PRF: 2.3 ± 1.4 (*P* < .05) 1 month: CCS: 1.8 ± 1.2; PRF: 2.5 ± 1.4 (*P* < .05) 2 months: CCS: 2.9 ± 1.4; PRF: 2.5 ± 1.3 (ns) 6 months: CCS: 3.2; PRF: 2.7 ± 1.5 (ns)	Hyperglycemia CCS: 1/30; PRF: 0/30	Both IA PRF and CCS significantly relieved FJ pain, and their effects were sustained for at least 6 months after the procedure. The short-term effect was higher after IA CCS, but the long-term effect was not significantly different between the two groups.
Juch 2017[40]	GPE (success, %) 3 weeks: PT: 4.95, CRF: 29.63 (*P* < .001) 6 weeks: PT: 9.32; CRF: 29.41 (*P* = .005) 3 months: PT: 23.68; CRF: 26.13 (ns) 6 months: PT: 36.11; CRF: 40.70 (ns) 9 months: PT: 40; CRF: 38.67 (ns) 12 months: PT: 39.22; PRF: 42.71 (ns) No significant intergroup differences in terms of NRS, RAND-36, EQ-5D, MPI and ODI.	None	RF denervation combined with a standardized exercise program resulted in either no improvement or no clinically important improvement in chronic low back pain compared with a standardized exercise program alone.
Kennedy 2018[41]	Not shown due to dropout of over 75% of enrolled subjects prior to the first scheduled follow up at 6 weeks.	Not reported	IA CCS was not effective in reducing the need for subsequent RF.
Kroll 2008[30]	No significant intergroup differences in terms of VAS and ODI.	None	No significant differences in pain relief or functional improvement were found between the randomized groups.
Lakemeier 2013[31]	No significant intergroup differences in terms of VAS, RMQ and ODI.	None	FJS can be treated with IA CCS or RF denervation with appropriate pain relief and functional improvement over at least 6 months, with no differences between treatments.

(continued)

Table 3. (continued)

Study	Outcomes	Complications	Conclusions
Leclaire 2001[32]	ODI Baseline: Sham: 36.4 ± 14.6; CRF: 38.3 ± 14.7, ns 1 month: Sham: 34.4; CRF: 35.6, ($P < .05$) 3 months: Sham: 33.7; CRF: 33.6, ns RMQ Baseline: Sham: 51.6 ± 22.8; CRF: 52.9 ± 18.2, ns 1 month: Sham: 49.5; CRF: 44.5, ($P < .05$) 3 months: Sham: 44.4; CRF: 43.1, ns No significant intergroup differences in terms of VAS, low back mobility and return to work.	None	RF FJ denervation in the treatment of chronic low back pain has not proved to be effective, as determined by functional disability at 12 weeks.
Manchikanti 2001[44]	No significant intergroup differences in terms of pain, overall health, narcotic intake, and employment status.	None	MDB with or without CCS but with local anesthetic and Sarapin were effective in providing significant pain relief, improvement in functional status, improvement in overall psychological status, and return to work.
Manchikanti 2010[42]	No significant intergroup differences in terms of NRS, ODI, narcotic intake and employment status.	None	CCS and Sarapin used in combination with local anesthetic, did not differ significantly in their response. The small differences between the two treatments are unlikely to be of clinical importance even in larger studies.
Moussa 2020[33]	VAS (mean change) 3 months: PRF: 8.3 ± 1 (DRG), 5.2 ± 1 (MDB); sham: 5.1 ±1.3 ($P = .014$) 6 months: PRF: 8.1 ± 1.2 (DRG), 5 ± 1.1 (MDB); sham: 2.1 ± .4 ($P = .013$) 1 year: PRF: 7.9 ± 1 (DRG), 4.8 ± 1 (MDB); sham: .6 ± .4 ($P = .01$) 2 years: PRF: 7.7 ± .7 (DRG), 2.1 ± .5 (MDB); sham: .5 ± .2 ($P = .006$) 3 years: PRF: 7.5 ± 1 (DRG), 2 ± .6 (MDB); sham: .3 ± .2 ($P = .003$) ODI (mean change) 3 months: PRF: 50.5 (DRG), 34.9 (MDB); sham: 33.6 ($P = .048$) 6 months: PRF: 48.1 (DRG), 30.3 (MDB); sham: 10.8 ($P = .032$) 1 year: PRF: 43.9 (DRG), 26.4 (MDB); sham: 5.5 ($P = .011$) 2 years: PRF: 39.3 (DRG), 15.3 (MDB); sham: 3.7 ($P = .008$) 3 years: PRF: 39.2 (DRG), 6.3 (MDB); sham: 2 ($P = .004$) GPE (more than 50% improvement, %) 3 months: PRF: 80 (DRG), 60 (MDB); sham: 50 ($P = .048$) 6 months: PRF: 74 (DRG), 42 (MDB); sham: 12 ($P = .035$) 1 year: PRF: 70 (DRG), 30 (MDB); sham: 4 ($P = .017$) 2 years: PRF: 64 (DRG), 10 (MDB); sham: 2 ($P = .005$) 3 years: PRF: 62 (DRG), 6 (MDB); sham: 0 ($P = .001$) WHO analgesics intake score (mean reduction) 3 months: PRF: 2.4 (DRG), 2 (MDB); sham: 2 ($P = .042$) 6 months: PRF: 2.3 (DRG), 1.9 (MDB); sham: .8 ($P = .035$) 1 year: PRF: 2.1 (DRG), 1.8 (MDB); sham: .2 ($P = .03$) 2 years: PRF: 2 (DRG), .6 (MDB); sham: .1 ($P = .007$) 3 years: PRF: 1.9 (DRG), .5 (MDB); sham: .1 ($P = .003$)	Not reported	In patients with FJS, targeting the DRG with PRF treatment presents both a higher efficacy as well as a longer duration of LBP control when compared to traditionally targeting the MDB with. The protracted therapeutic benefit obtained by targeting the DRG became evident starting at 2 years' follow-up and was still evidently recorded at 3 years' follow-up, manifesting in a persistently significant improvement in VAS score whereas targeting the MDB lost its significant therapeutic effect.

(continued)

Table 3. (continued)

Study	Outcomes	Complications	Conclusions
Nath 2008[34]	VAS Baseline: Sham: 4.35; CRF: 6.03 6 months: Sham: 3.98; CRF: 4.10 (P = .02 from baseline) Analgesic intake (6-point scale) Baseline: Sham: 3.80; CRF: 3.95 6 months: Sham: 3.2; CRF: 2.55 (P = .04) Subjective global assessment (6-point scale) Baseline: Sham: 3.35 CRF: 3.85 6 months: Sham: 3.05; CRF: 2.75 (P = .004)	None	RF facet denervation may be considered in the treatment of carefully selected patients alongside other treatment methods.
Sae-Jung 2016[35]	VAS Baseline: OD: 7.1 ± 1.2; CCS: 7.6 ± 1.1; CT: 7.3 ± 1 (ns) 1 month: OD: 5.3 ± 1.4; CCS: 3.6 ± .7; CT: 3.3 ± 1.1 (P < .001) 3 months: OD: 6.1 ± 1.1; CCS: 5.8 ± 1.4; CT: 5.1 ± .9 (P = .002) ODI Baseline: OD: 45.1 ± 9.3; CCS: 42.9 ± 15.6; CT: 42.2 ± 11.5 (ns) 1 month: OD: 30.1 ± 8.1; CCS: 20.2 ± 8; CT: 15.1 ± 5.5 (P < .001) 3 months: OD: 42.4 ± 9; CCS: 32.2 ± 15.6; CT: 26.2 ± 11.7 (P < .001)	Dyspepsia (%): OD + CT: 12, CCS: 0 Post-injection discomfort (%) OD: 0; CCS + CT: 44	The combination of oral diclofenac and methylprednisolone facet injections is an effective short-term treatment of FJS, with or without associated thigh pain. The benefits are strongest within the first 4 weeks of treatment and diminish over the next 12 weeks.
van Tilburg 2016[43]	No significant intergroup differences in terms of NRS and GPE.	None	No difference in either pain or in GPE between the treatment and sham groups was found when using RF for FJS.
Wu 2017[38]	VAS Significantly lower scores in the CCS + lidocaine group at 1 week and 1 month (P < .01) and in the PRP group at 3 and 6 months (P < .01) ODI Significantly lower scores in the CCS + lidocaine group at 1 week and 1 month (P < .01) and in the PRP group at 2,3 and 6 months (P < .01). RMQ Significantly lower scores in the CCS + lidocaine group at 1 week and 1 month (P < .01) and in the PRP group at 3 and 6 months (P < .01). Modified MacNab criteria No significant intergroup differences at 1 week, 1, 2 and 3 months. 6 months: PRP: excellent (53.38%), good (28.57%), fair (9.52%), poor (9.52%); CCS + lidocaine: excellent (20%), good (30%), fair (30%), poor (20%)	Post-injection LBP (%): PRP: 33.3%; CCS + lidocaine: 25%	Both PRP and CCS + lidocaine are effective, easy, and safe options for treating FJS. However, PRP is a superior treatment for longer duration efficacy.
Yasar 2018[36]	VAS Baseline: CCS: 6.4 ± .9; PRF: 5.8 ± 1 (ns) 3 months: CCS: 3.3 ± 1; PRF: 2.5 ± 1 (P < .05) 6 months: CCS: 3.3 ± .9; PRF: 2.3 ± 1.4 (P < .05) 9 months: CCS: 2.5 ± 1; PRF: 2.7 ± .9 (ns) 12 months: CCS: 3 ± 1.5; PRF: 3 ± 1.1 (ns) ODI Baseline: CCS: 57.2 ± 13.9; PRF: 58.5 ± 13.1 (ns) 3 months: CCS: 24.1 ± 8.7; PRF: 18.9 ± 5.7 (P < .05) 6 months: CCS: 24.8 ± 9.5; PRF: 14.9 ± 7 (P < .05) 9 months: CCS: 12.2 ± 3.8; PRF: 10.4 ± 2.8 (ns) 12 months: CCS: 12.1 ± 4.4; PRF: 17.2 ± 6.4 (ns)	Post-injection LBP (n) 4/100	CCS injection should be used as the first choice of treatment before RF in patients with FJS if there are no contraindications.

(continued)

Table 3. (continued)

Study	Outcomes	Complications	Conclusions
Zhou 2016[37]	VAS Baseline: CCS: 6.8; CRF: 6.7 (ns) 30 min: CCS: 3.6; PRF: 3.5 (ns) 1 day: CCS: 2.7; PRF: 2.7 (ns) 1 week: CCS: 1.9; PRF: 1.4 (ns) 1 month: CCS: 3.6; PRF: 1.4 ($P < .05$) 12 months: CCS: 5.8; PRF: 1.7 ($P < .05$) Schober index Baseline: CCS: 6.85 CRF: 6.6 (ns) 1 week: CCS: 8.9; PRF: 9 (ns) 1 month: CCS: 7.3; PRF: 8.6 ($P < .01$) 12 months: CCS: 6.2; PRF: 8.8 ($P < .05$) Half year efficacy (%): Excellent: CCS 12.5; PRF 62.5 Good: CCS 30; PRF 27.5 Eligible: CCS 5; PRF 7.5 Poor: CCS 52.5; PRF 2.5	None	X-ray-guided RF thermocoagulation denervation is an effective, minimally invasive, and convenient method for treating LBP secondary to FJS.

Abbreviations: CCS, corticosteroids; CRF, continuous radiofrequency; CT, combined treatment; DRG, dorsal root ganglion; EQ-5D, European Quality of Life 5 Dimensions; FJ, facet joint; FJS, facet joint syndrome; GPE, Global Perceived Effect; HA, hyaluronic acid; IA, intraarticular; LBP, low back pain; MDB, medial dorsal branch; NRS, numeric rating scale; OD, oral diclofenac; ODI, Oswestry Disability Index; PDQ, Patient Disability Questionnaire; PRF, pulsed radiofrequency; PRP, platelet-rich plasma; PT, physical therapy, RF, radiofrequency; RMQ, Roland-Morris Questionnaire; VAS, visual analogue scale, WHO, World Health Organization.

Surgical Efficacy Criteria of the Spine Surgery Group (Orthopedic Branch of Chinese Medical Association), an excellent outcome was reached by 12.5% patients in the CCS group and 62.5% in the PRF group; a good outcome in 30% of the patients treated with CCS and 27.5% with PRF; an eligible outcome in 5% and 7.5%, respectively; a poor outcome in 52.5% in the former and 2.5% in the latter.

In the study by Do et al.,[39] NRS scores significantly improved compared to the baseline (CCS: 5.0 ± .8; PRF: 4.9 ± .8) at all timepoints after the procedure. However, NRS was significantly lower in the CCS group at 2 weeks (CCS: 1.4 ± .8; PRF: 2.3 ± 1.4, $P < .05$) and 1 month (CCS: 1.8 ± 1.2; PRF: 2.5 ± 1.4, $P < .05$), but not at later follow-ups (2 months: CCS: 2.9 ± 1.4, PRF: 2.5 ± 1.3; 6 months: CCS: 3.2, PRF: 2.7 ± 1.5). In the CCS group, 1 patient developed hyperglycemia (> 300 mg/dL).

Juch et al.[40] compared the efficacy of CRF combined with physical therapy (PT) vs PT alone. Authors reported that the satisfaction rate calculated with GPE in the CRF group was significantly higher at 3 (PT: 4.95%, CRF: 29.63%, $P < .001$) and 6 weeks (PT: 9.32%; CRF: 29.41%, $P = .005$), but not at other timepoints (3 months: PT: 23.68%, CRF: 26.13%; 6 months: PT: 36.11%, CRF: 40.70%; 9 months: PT: 40%, CRF: 38.67%; 12 months: PT: 39.22%, PRF: 42.71%. In addition, no significant intergroup differences in terms of NRS, RAND-36, EQ-5D, MPI and ODI were retrieved.

The effect of RF FJ denervation was compared to a sham control in 4 studies.[32-34,43]

Leclaire et al.[32] showed that patients in the CRF group reported a significant improvement of ODI (sham: 34.4; CRF: 35.6, $P < .05$) and RMQ (sham: 49.5; CRF: 44.5, $P < .05$) at 1 month compared to baseline (ODI: sham: 36.4 ± 14.6, CRF: 38.3 ± 14.7; RMQ: sham: 51.6 ± 22.8; CRF: 52.9 ± 18.2) but not at 3 months (ODI: sham: 33.7, CRF: 33.6; RMQ: sham: 44.4, CRF: 43.1). Similarly, no significant intergroup differences in terms of VAS, low back mobility (flexion, extension, side-bending, and rotations, maximal strength against resistance, and angular speed against 25% of the maximum strength resistance) and return to work were encountered.

Likewise, van Tilburg et al.[43] reported a decrease of pain scores following the treatment but no significant differences between the two groups regarding NRS and GPE.

In their study, Moussa et al.[33] compared PRF of the dorsal root ganglion (DRG) or the medial dorsal branch (MDB) with a sham procedure. Patients undergoing DRG RF showed a significantly higher improvement of VAS scores at all timepoints compared to other groups (3 months: PRF: 8.3 ± 1 (DRG), 5.2 ± 1 (MDB), sham: 5.1 ±1.3, $P = .047$; 6 months: PRF: 8.1 ± 1.2 (DRG), 5 ± 1.1 (MDB), sham: 2.1 ± .4, $P = .031$; 1 year: PRF: 7.9 ± 1 (DRG), 4.8 ± 1 (MDB), sham: .6 ± .4, $P = .008$; 2 years: PRF: 7.7 ± .7 (DRG), 2.1 ± .5 (MDB), sham: .5 ± .2, $P = .006$; 3 years: PRF: 7.5 ± 1 (DRG), 2 ± .6 (MDB), sham: .3 ± .2, $P = .003$). Similarly, mean changes of ODI scores were significantly higher in the DRG group compared to the others (3 months: PRF: 50.5 (DRG), 34.9 (MDB), sham: 33.6, $P = .048$; 6 months: PRF: 48.1 (DRG), 30.3 (MDB), sham: 10.8, $P = .032$; 1 year: PRF: 43.9 (DRG), 26.4 (MDB), sham: 5.5, $P = .011$; 2 years: PRF: 39.3 (DRG), 15.3 (MDB), sham: 3.7, $P = .008$; 3 years: PRF: 39.2 (DRG), 6.3 (MDB), sham: 2, $P = .004$). Patients receiving DRG RF also reported a higher rate of GPE improvement (> 50%) when compared to MDB RF and sham groups (3 months: PRF: 80 (DRG), 60 (MDB), sham: 50, $P = .048$; 6 months: PRF: 74 (DRG), 42 (MDB), sham: 12, $P = .035$; 1 year: PRF: 70 (DRG), 30 (MDB), sham: 4, $P = .017$; 2 years: PRF: 64 (DRG), 10 (MDB); sham: 2,

$P = .005$; 3 years: PRF: 62 (DRG), 6 (MDB), sham: 0, $P = .001$). In addition, a more consistent mean reduction of the WHO analgesics intake score was recorded in patients following RF, especially in the DRG group (3 months: PRF: 2.4 (DRG), 2 (MDB); sham: 2, $P = .042$; 6 months: PRF: 2.3 (DRG), 1.9 (MDB); sham: .8, $P = .035$; 1 year: PRF: 2.1 (DRG), 1.8 (MDB), sham: .2, $P = .03$; 2 years: PRF: 2 (DRG), .6 (MDB); sham: .1, $P = .007$; 3 years: PRF: 1.9 (DRG), .5 (MDB), sham: .1, $P = .003$).

Nath et al.[34] reported a more consistent reduction of VAS scores in the CRF group at 6 months compared to baseline (CRF: 4.10 vs 6.03; sham: 3.98 vs 4.35), and this difference was statistically significant ($P = .02$). Similarly, patients in the CRF group displayed a significant improvement of 6-point scales regarding analgesic intake (CRF: 2.55 vs 3.95; sham: 3.2 vs 3.80, $P = .04$) and subjective global assessment (CRF: 2.77 vs 3.85; sham: 3.05 vs 3.35, $P = .004$) at the same timepoint.

IA CCS. Kennedy et al.[41] compared the injection of IA CCS (20 mg triamcinolone) with IA saline. As > 75% of enrolled patients in both groups underwent RF neurotomy before the first scheduled follow-up at 6 weeks, no data pertaining NRS and ODI were presented. However, no statistically significant difference in either the need to progress to or time to RF was reported in any group.

Manchikanti and colleagues[44] evaluated the effect of an IA injection of a mixture of methylprednisolone, lidocaine or bupivacaine and Sarapin compared to the same preparation without CCS. No significant intergroup differences in terms of pain, overall health, narcotic intake, and employment status were encountered. In another study, the same authors utilized a blend of bupivacaine and betamethasone with or without Sarapin compared with bupivacaine alone or mixed with Sarapin.[42] Similar to their previous study, no statistically significant difference regarding NRS, ODI, narcotic assumption and employment was reported between groups.

Sae-Jung et al.[35] compared the efficacy of IA CCS (80 mg methylprednisolone) and oral diclofenac (50 mg twice daily for 2 weeks) vs oral diclofenac (OD) or IA CCS alone. Patient receiving the combined treatment (CT) showed a higher improvement of ODI compared to other groups at 1 month (OD: 30.1 ± 8.1; CCS: 20.2 ± 8, CT: 15.1 ± 5.5; $P < .001$ CT vs OD; $P = .02$ CT vs CCS) and to the OD group at 3 months (OD: 42.4 ± 9; CCS: 32.2 ± 15.6, CT: 26.2 ± 11.7, CT vs OD, $P < .001$ CT vs OD; $P = .15$ CT vs CCS). Likewise, VAS scores were significantly lower in the CT group compared to the OD group (but similar to CCS alone) at 1 month (OD: 5.3 ± 1.4; CCS: 3.6 ± .7, CT: 3.3 ± 1.1; $P < .001$ CT vs OD; $P = .76$ CT vs CCS) and 3 months (OD: 42.4 ± 9, CCS: 32.2 ± 15.6, CT: 26.2 ± 11.7, $P = .002$ CT vs OD; $P = .08$ CT vs CCS). 12% of patients receiving OD presented dyspepsia, while post-injection discomfort was reported in 44% of patients following IA CCS.

IA PRP. Wu et al.[38] conducted a prospective RCT comparing IA FJ injection of .5 mL autologous PRP with .5 ml CCS and local anesthetic (.4 mL .5% lidocaine and .1 mL 5 mg/mL betamethasone). Significantly lower VAS scores were encountered in both groups at all timepoints (1 week, 1 month, 2 months, 3 months and 6 months, $P < .01$) except immediately following injection. VAS decreased more consistently in the group treated with CCS and lidocaine at 1 week and 1 month ($P < .01$), although the group treated with PRP showed a better pain relief at 3 and 6 months ($P < .01$). The ODI and RMQ showed a similar trend, with higher scores at earlier timepoints in the former group ($P < .01$) and at later follow-up intervals in the latter ($P < .01$). Regarding satisfaction, modified MacNab criteria showed no significant intergroup difference except at 6 months, when the number of patients in the PRP group declaring "excellent" (52.38%) and "good" (28.57%) outcomes were significantly higher compared to individuals in the other group (20% and 30%, respectively; $P < .05$). The 50% pain improvement threshold was reached by 85% of patients treated with CCS and lidocaine at 1 week and 1 month, while it was reported by 80.95% in the PRP group at 3 and 6 months. Furthermore, 40% of patients in the former group used acetaminophen for pain relief, whereas only 23.81% utilized in the PRP group.

Discussion

LBP represents a major global problem affecting more than 500 million people, being the leading global cause of disability. FJS is often a misdiagnosed and inadequately treated condition but constitutes a common source of LBP that must be properly addressed. Conservative treatment can provide a valid alternative for the treatment of FJS. In this regard, several minimally invasive nonsurgical procedures have been developed to deliver specific therapeutics in proximity of FJs.

For selected studies with FJS associated with chronic LBP, the use of these approaches overall produces a significant long-term improvement in pain and functional scores, although with considerable differences among the different techniques. CCS play a dual role in the management of pain in osteoarthritis, as they interrupt nociceptive inputs at central and peripheral level and mitigate the pro-inflammatory environment in affected joints.[45] In our analysis, we included 4 studies evaluating FJ injections with CCS compared to a control group without CCS.[35,41,42,44] Among these, 1 study reported a lack of efficacy in reducing the need for subsequent RF,[41] while other 2 studies showed no significant intergroup differences in terms of pain, overall health, analgesics intake and employment status.[42,44] Only 1 study reported a significant improvement of VAS and ODI at 1 and 3 months with the use of IA CCS, although in combination with oral diclofenac.[35]

Overall, clinical outcomes after FJ block appear very heterogeneous, and may be affected by the use of different steroids and local anesthetics in the treatment and control groups. Furthermore, all reported studies presented a short follow-up with a maximum of 6 months. Given these limitations, it is difficult to

assess the role of FJ injections in the management of FJ-induced LBP and the level of evidence remains low (III).

Compared to CCS, HA has a different therapeutic activity, as it aims to rebalance the elastic and viscous properties of the synovial fluid.[46] One study showed the efficacy of IA with HA in providing an overall VAS improvement of 42% at 6 months, without any significant difference compared with CCS, although HA resulted in a significant functional benefit at 6 months.[27] The clinical efficacy of HA has been tested in other clinical settings, such as knee osteoarthritis.[47] However, the efficacy of HA may be limited by the anatomy of FJs, since this compound is injected a restricted intracapsular anatomical space and it is difficult to establish how much actually reaches the joint surface between the two articular processes in order to produce clinical benefits.

The use of PRP for FJS was reported only in 1 study.[38] PRP is a blood derivative mainly containing a large number of growth factors, including including platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), fibroblast growth factor (FGF), insulin-like growth factor 1 (IGF-1), connective tissue growth factor (CTGF), and epidermal growth factor (EGF), as well as additional bioactive factors that have shown anabolic and anti-inflammatory properties in several tissues, including cartilage, tendon and the intervertebral disc.[48] Therefore, it is widely used to treat an increasing range of degenerative musculoskeletal disorders, especially osteoarthritis and tendinopathies.[49] In the RCT conducted by Wu et al.,[38] PRP was compared to CCS and a local anesthetic. Although LBP transiently increased in both groups following injection, pain and disability improved more significantly in the latter group at earlier timepoints (until 2 months), while patients receiving PRP showed better outcomes at later follow-ups (3 and 6 months). Similarly, the satisfaction rate at 6 months was significantly higher in patients in the PRP group. These differences may indicate that CCS are effective in the short term, whereas PRP may present a longer duration efficacy.

Regarding the use of RF ablation, out of the 12 studies included in this analysis, 7 studies demonstrated both short-term and long-term efficacy,[28-30,33,34,36,37] 2 trials revealed only short-term efficacy,[31,39] whereas 3 studies showed a lack of effectiveness.[32,40,43] Four studies compared RF ablation with a sham group: in the study by Nath et al.,[34] RF was associated with a significant decrease of VAS and analgesic intake at 6 months, while Leclaire[32] and van Tilburg[43] did not find any significant difference in pain scores, ODI and patient satisfaction. However, RF ablation may have different outcomes depending on the nerve structures undergoing neurolysis. Not by chance, Moussa and colleagues[33] investigated two different RF targets, showing that RF performed on the dorsal root ganglion had the best outcomes in term of VAS and ODI at all timepoints compared to RF targeting the medial dorsal branch. Another factor which may influence the efficacy of nerve ablation is the modality of RF, which include continuous (traditional) or pulsed RF, and this has been investigated by 2 of the included studies,[28,30] although with different results. Cetin et al.[28] found a better short-term VAS using continuous RF, while better long-term pain scores were showed using pulsed RF. On the contrary, Kroll and colleagues[30] did not find any significant difference between groups.

Five studies compared RF for FJ denervation with CCS IA injections [29,31,36,37,39]: most of these found comparable short-term pain and functional outcomes, although RF was demonstrated to be superior at 6 and 12 months in 3 studies,[29,36,37] while 2 studies did not found long-term significant differences between groups.[31,39] However, despite the better long-term outcome related to the use of RF, 2 cases of postprocedural neuropathic pain have been described by Civelek et al.,[29] while other 3 cases by Cetin and colleagues.[28] On the other hand, adverse events of IA CCS may include transient hyperglycemia.[39,50]

This systematic review revealed a level II evidence for short-term effectiveness of 6 months or less and for long-term effectiveness of 6 months or longer about the use of RF for chronic LBP due to FJS. These results confirm the recommendations from the American Society of Interventional Pain Physicians (ASIPP) guidelines for FJ interventions.[51]

This review has several limitations. The inclusion of patients with different comorbidities may have introduced a bias in the evaluation of the results, as pain originating from structures other than FJs may respond differently to the injection therapy. Moreover, previous spinal surgery did not represent an exclusion criterion for most of the included studies. This may represent a source of bias, since surgical complications, such as adhesions, hematomas, bony and soft tissues compressions may lead to LBP, which might occasionally confuse the diagnosis. Furthermore, while statistically significant differences were effectively reported in most studies, mean changes in outcome measures did not always reach clinical significance. For example, the minimal clinically important differences (MCID) of VAS and ODI scores, reportedly 2[52] and 12.88[53] respectively, have not been met by most studies reporting statistically significant improvements of such outcome measures.[28,29,32,34-36] Therefore, results of these studies should be interpreted with further caution. Finally, given the lack of quantitative data regarding the IA drugs used for FJ injections, studies reporting outcomes from combined treatments were considered in this review. For the same reason, the heterogeneity of the data analyzed prevented a meta-analysis to be performed.

Conclusion

FJS is a common cause of LBP that can be managed with several different strategies. In the last decade, a growing number of minimally invasive approaches has been developed to either reduce FJ inflammation, enhance joint lubrication, directly target FJ sensory innervation, or a combination of these. According to our analysis, the use of these techniques has provided mixed results, with overall little short-term or no

benefits on pain, disability, and other investigated outcomes. This can be partly explained by the substantial heterogeneity affecting utilized techniques and included populations as well as by the complexity of LBP, which may present several pain generators other than FJs alone.

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Supplemental Material

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