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Radiofrequency neurotomy in chronic lumbar and sacroiliac joint pain

A meta-analysis

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Abstract

Background: Effective treatment of low back pain (LBP) originating in the lumbar and sacroiliac joints is difficult to achieve. The objective of the current study was to compare the clinical effectiveness of radiofrequency (RF) neurotomy versus conservative nonsurgical approaches for the management of chronic lumbar and sacroiliac joint pain.

Methods: The PICOS framework was adhered to (P [population]: patients with a history of chronic function-limiting lumbar and sacroiliac joint pain lasting at least 6 months; I [intervention]: RF neurotomy; C [comparator]: other nonsurgical treatments; O [outcomes]: the Oswestry Disability Index (ODI), measurement for pain, and a quality of life (QoL) questionnaire; S [study design]: meta-analysis). Two trained investigators systematically searched Medline, Cochrane, EMBASE, and ISI Web of Knowledge databases for relevant studies published in English through March 2019.

Results: Patients treated with RF neurotomy (n=528) had significantly greater improvement in ODI scores, pain scores and QoL measured by EQ-5D compared with controls (n=457); however, significant heterogeneity was observed when data were pooled from eligible studies. In subgroup analyses, patients who received RF neurotomy had a significantly greater improvement in ODI scores compared with those with sham treatment. Patients treated with RF achieved significantly greater improvement in pain scores compared with controls who received sham treatment or medical treatment. In a subgroup analysis of pain in the sacroiliac joint and in lumbar facet joints, the RF neurotomy group achieved a significantly greater improvement in ODI score and pain scores compared with the control group. The ODI score and pain score were improved after 2 months of follow up in the analyses stratified by follow-up duration.

Conclusions: Use of RF neurotomy as an intervention for chronic lumbar and sacroiliac joint pain led to improved function; however, larger, more directly comparable studies are needed to confirm this study's findings.

Abbreviations: LBP = low back pain, NRS = numerical rating scale, ODI = Oswestry Disability Index, QoL =quality of life, RCT = randomized controlled trial, RF = radiofrequency, VAS= Visual Analogue Scale, VNS = Visual Numeric Pain Scale.

Keywords: chronic lumbar and sacroiliac joint pain, denervation, meta-analysis, radiofrequency neurotomy

1. Introduction

Although low back pain (LBP) originating in the lumbar and sacroiliac joints is a common complaint, it is often difficult to reach a definitive diagnosis for these patients and thus to provide effective treatment.[1] Lumbar facet joints have been implicated as the source of chronic pain in 21% to 41% of patients, as reported in 1 heterogeneous population with chronic LBP.[2] It is also generally accepted that approximately 16% to 30% of patients with persistent LBP have pain arising from their sacroiliac joints.[3] Traditionally, lumbar and sacroiliac joint pain has been managed with intra- and extra-articular steroid injections. A more recent alternative is neurolysis, which is accomplished using several forms of radiofrequency (RF), including conventional RF neurotomy and cooled RF neurotomy.[4]

RF thermocoagulation, also known as conventional RF denervation, continuous RF lesioning, or RF ablation, is a minimally invasive procedure that has been used for more than 30 years.[5] It relies on RF-generated thermal energy to ablate the sensory nerve fibers of the sacroiliac joint, thereby interrupting nociceptive signals. Due to inconsistent sensory distribution to

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the sacroiliac joint, the use of RF denervation to treat sacroiliac joint pain has produced conflicting results.[6–9]

Cooled RF is a novel technique in which internally cooled RF probes produce larger lesions than is possible with other approaches.[7,10] The primary advantage of cooled RF technology is that it doubles the lesion's diameter and enhances the volume by a factor of 8, making it more likely to interrupt the nociceptive input from the sacroiliac joints.[11,12]

The efficacy of cooled RF neurotomy in managing sacroiliac joint pain has been established based on 2 randomized, double-blind placebo-controlled trials.[12,13] Evidence of the effectiveness of conventional RF is less compelling.[1]American Society of Interventional Pain Physicians guidelines and a systematic review concluded that lumbar facet joint nerve blocks did provide both short- and long-term improvement,[14,15] but these findings failed to be proven in 2 systematic reviews.[16,17] Thus, the effects of RF have not been demonstrated clinically.

To address these conflicting study results, we designed and completed a meta-analysis of studies that compared RF interventions with other conventional nonsurgical approaches for the management of chronic LBP arising from both lumbar facet joints and sacroiliac joints.

2. Patients and methods

2.1. Selection criteria

This systematic review and meta-analysis were conducted in accordance with PRISMA guidelines for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions.[18] Ethical approval and informed consent were not necessary as the meta-analyses did not involve human subjects and were therefore exempt from Institutional Review Board approval.

The study was guided by the PICOS framework.[19] P (population): patients with a history of chronic function-limiting lumbar and sacroiliac joint pain lasting at least 3 months. I (intervention): RF neurotomy (including conventional and cooled). C (comparator): other nonsurgical treatments, including intra-articular injections of either corticosteroids or local anesthetics, anti-inflammatory medication, and sham treatments. O (outcomes): the Oswestry Disability Index (ODI), a measurement for pain such as the Visual Analogue Scale (VAS), numerical rating scale (NRS), or Visual Numeric Pain Scale (VNS), and a quality of life (QoL) questionnaire. All clinical outcomes were reported within 3 to 6 months after the interventions. S (study design): meta-analysis including only randomized controlled trials (RCTs). Only English-language publications were included. Data extraction was performed by 2 independent reviewers, with a third reviewer consulted in case of any disagreements.

Letters, comments, editorials, case reports, proceedings, personal communications, and non-English publications were excluded from the analysis. Additional exclusion criteria were: patients with radicular pain, discogenic pain, surgical interventions of the lumbar spine within the previous 3 months, patients treated with pulsed RF, and patients with uncontrolled major depression, psychiatric disorders, opioid addiction, or dependence; studies involving other types of interventions, such as spinal injections or acupuncture; and any study design that had qualitative primary or secondary outcomes.

2.2. Search strategy

Trained investigators searched articles listed in the Medline, Cochrane, EMBASE, and ISI Web of Knowledge databases published through March 2019. The reference lists of relevant studies were also reviewed. Keywords used for the search included: RF neurotomy, denervation, lumbar pain, and sacroiliac joint pain. Supplementary Table 1, http://links.lww.com/MD/D68 presents details of our search strategies for each database consulted.

2.3. Study selection and data extraction

Studies were identified by 2 independent reviewers using the search strategy. A third reviewer was consulted as needed if/when there was uncertainty regarding study eligibility. The following data were extracted from studies that met the inclusion criteria: the name of the first author, year of publication, study design, number of participants in each treatment group, participants' ages and sexes, and scores from: the ODI, the measurement for pain, and the QoL assessment.

2.4. Quality assessment

The included studies were assessed for risk of bias using the Cochrane Risk of Bias Tool.[20] Quality assessment was performed by the independent reviewers, and a third reviewer was consulted if/when questions arose.

2.5. Outcome measures

The primary outcome measures were the ODI (measured 3–6 months after intervention); the scales for pain, including VAS, NRS, and VNS (reported at 3–6 months after intervention); and QoL, including EQ-5D, Global Perceived Effect (GPE)-satisfaction, SF-36 bodily pain and SF-36 physical functioning (reported 3–6 months after intervention).

2.6. Statistical analysis

All outcomes were assessed during the follow-up period of 3 to 6 months. The difference in means was calculated for the 3 outcomes in the RF neurotomy group compared with those in the control group (i.e., the group receiving intra-articular injections of corticosteroids or local anesthetics, or oral anti-inflammatory medication, or sham interventions). Heterogeneity among the studies was assessed using the Cochran Q test and the I^2 statistic. For the Q statistic, $P<.10$ was considered statistically significant for heterogeneity. The I^2 statistic indicated the percentage of the observed between-study variability due to heterogeneity rather than chance, using the following ranges: no heterogeneity ($I^2=$ 0%–25%), moderate heterogeneity ($I^2=25\%–50\%$), large heterogeneity ($I^2=50\%–75\%$), and extreme heterogeneity ($I^2=75\%–100\%$). The random-effects model was used for all analyses (DerSimonian–Laird method). If more than 10 studies are included in the study for each study outcome, a funnel plot is constructed in order to detect publication bias.[28] Egger regression intercept approach was used to examine the symmetry of the funnel plot. The pooled difference in the means of the outcomes was calculated, and a 2-sided P-value $<.05$ was considered statistically significant. All statistical analyses were performed using the statistical software package Comprehensive Meta-Analysis, version 2.0 (Biostat, Englewood, NJ).

Table 1

Characteristics of the 15 studies included in the meta-analysis.

Author (yr)	Comparison	No. of subjects	Age*	Male (%)	Subjects' type(s) of chronic lumbar and sacroiliac joint pain	Interventions
Mehta (2018)[28]	RF neurotomy	11	56.6	NA	SIJ pain	RF denervation of the L5 medial branch of the primary dorsal root nerve and the lateral branches of the S1, S2, and S3 nerve roots
	Sham procedure	6	62.6	NA		The sham procedure was identical to the RF treatment except that no RF energy was applied
Moussa (2016)[29]	Percutaneous RF- Joint capsule denervation	40	58.1	27.5	LFJ pain	Each facet joint capsule received two lesions, one on its medial aspect and a second one on the lateral aspect
	Percutaneous RF- Medial dorsal branch denervation	40	56.5	22.5		RF denervation of the junction of the superior articular process and the transverse process where the medial dorsal branch courses
	Sham procedure	40	55.9	32.5		The sham procedure was identical to the RF treatment except that no RF energy was applied
van Tilburg (2016a)[27]	Percutaneous RF heat lesion	30	59.5 (27)†	16.7	SIJ pain	RF denervation of the ramus dorsalis of L5 and lateral branches of S1-S4
	Sham procedure	30	62 (18)†	16.7		The sham procedure was identical to the RF treatment except that no RF energy was applied
van Tilburg (2016b)[25]	Percutaneous RF heat lesion	30	65 (12)†	46.7	LFJ pain	RF denervation of the L5/S1 level, the adjacent L4/L5 level
	Sham procedure	30	58 (12)†	40		The sham procedure was identical to the RF treatment except that no RF energy was applied
Zhou (2016)[30]	X-rays-guided RF neurotomy	40	56.5 (8.7)	23	LFJ pain	RF denervation of medial branch of spinal nerve
	Steroid injection	40	54.6 (7.5)	21		Injection of betamethasone and of lidocaine
Zheng (2014)[31]	Palisade sacroiliac joint RF neurotomy	82	41.3 (38.3, 44.2)‡	72	Ankylosing spondylitis with chronic low back pain originated from SIJ	A row of RF cannulae perpendicular to the dorsal sacrum to produce contiguous lesion between the dorsal sacral foramina and the SIJ line
	Celecoxib	73	43.3 (40.5, 46.1)‡	74		Oral celecoxib 200 mg twice daily for 24weeks
Lakemeier (2013)[21]	Conventional facet RF neurotomy	26	57.6 (12.8)	65	LFJ-related back pain for at least 24 months	RF denervation of L3/L4-L5/S1 segments
	Steroid injection	26	56.3 (10.8)	62		Intra-articular injections of betamethasone with bupivacaine
Civelek (2012)[22]	Conventional facet RF neurotomy	50	51.8 (17)	30	LFJ syndrome not responsive to injections of analgesics or physical therapy.	RF denervation of medial dorsal spinal ramus
	Steroid injection	50	56.5 (17.7)	29.2		Injections of methyl-prednisolone with bupivacane
Patel (2012)[12]	Cooled SIJ RF lateral branch neurotomy	34	56 (15)	32	With > 6 months axial LBP below L5 vertebrate unresponsive to nonoperative treatments including injections of corticosteroids.	Lateral branch neurotomy using cooled RF electrodes to ablate S1-S3 lateral branches and L5 dorsal ramus
	Sham procedure	17	64 (14)	18		Sham treatment was identical to active treatment except the RF energy was not delivered

(*continued*)

Table 1
(continued).

Author (yr)	Comparison	No. of subjects	Age*	Male (%)	Subjects' type(s) of chronic lumbar and sacroiliac joint pain	Interventions
Cohen (2008)[13]	Cooled SIJ RF lateral branch neurotomy	14	51.9 (13.6)	36	Chronic axial LBP injection diagnosed as SIJ pain	Neurotomy of L4-L5 primary dorsal rami and S1-S3 lateral branches using cooled RF electrodes after a local anesthetic block
	Sham procedure	14	51.8 (13.1)	43		Local anesthetic block followed by placebo denervation but with no delivery of energy
Nath (2008)[26]	RF neurotomy	20	56 (36, 79)§	30	Lumbar zygapophysial (Facet) Joint point	Denervation was achieved by multiple lesions along the nerve
	Sham procedure	20	53 (37, 76)§	45		Same procedures as study groups but no RF energy was delivered
Tekin (2007)[23]	Conventional RF neurotomy	20	60.5 (8.5)	45	LBP > 6 months with tenderness over facet joints and unresponsive to traditional conservative treatments,	Conventional RF at L1–L3 or L3–L5 including segmental medial branches
	Sham procedure	20	57.9 (9.3)	45		Same procedures as study groups but no RF energy was delivered
van Wijk (2005)[24]	Conventional facet RF neurotomy	40	46.9 (11.5)	25	LBP > 6 months with focal tenderness over facet joints	Conventional RF denervation of lumbar facet joint
	Sham procedure	41	48.1 (12.6)	31.7		RF electrodes and thermocouple probes were placed similarly but no RF current was delivered
Leclaire (2001)[32]	Percutaneous RF neurotomy	36	46.7 (9.3)	12	LBP > 3 months and a good response after intraarticular facet injections under fluoroscopy	RF neurotomy was performed at a minimum of two levels, usually at L4–L5 and L5–S1 unilaterally on the painful side or bilaterally
	Sham procedure	34	46.4 (9.8)	13		Same proceduresas study groups except that the temperature of the electrode tip was not raised, but maintained at 37°C
van Kleef (1999)[33]	RF neurotomay	15	46.6 (7.4)	33.3	LFJ pain	RF denervation of the medial branch of the posterior primary ramus of the segmental nervesL3-L5 on one or on both sides
	Sham	16	41 .4 (7.5)	37.5		RF electrodes and thermocouple probes were placed similarly but no RF current was delivered

LBP = low back pain; LFJ = lumbar facet joint; RF = radiofrequency; SIJ = sacroiliac joint; NA = not available.
* Data expressed as mean (standard deviation).
† Data expressed as median (interquartile range).
‡ Data expressed as mean (95% confidence interval).
§ Data expressed as median (range).

Study name	Statistics for each study: Difference in means	Lower limit	Upper limit	p-Value	Relative weight
Lakemeier (2013)	-7.10	-16.99	2.79	0.159	9.76
Patel (2012)	-13.00	-21.36	-4.64	0.002	12.46
Cohen (2008)	-5.30	-12.78	2.18	0.165	14.49
Tekin (2007)	-2.90	-6.16	0.36	0.081	30.36
Leclaire (2001)	-1.90	-6.73	2.93	0.441	23.20
van Kleef (1999)	-12.76	-22.68	-2.84	0.012	9.72
Pooled estimate	-5.64	-9.19	-2.10	0.002	

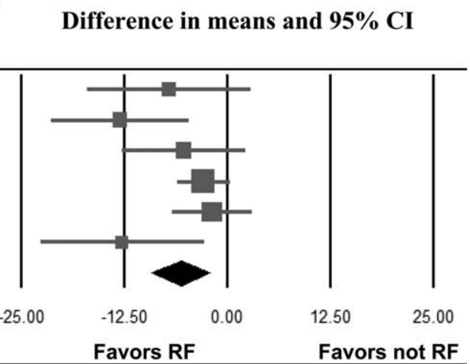


Figure 1. Forest plots showing meta-analysis results for ODI for all studies (RF vs non-RF). ODI=Oswestry Disability Index.

3. Results

3.1. Literature search

Of the 240 identified, a total of 153 eligible articles were found. Of these, 85 were excluded (i.e., for not satisfying all of the inclusion criteria or for satisfying 1 or more of the exclusion criteria). After full-text review of the remaining 68 articles, we excluded 7 studies due to lack of applicable outcomes, 36 that involved only single-arm studies, 7 studies with other objectives, and 3 for which the full texts were not available. Taken together, a total of 15 studies were included in the present report (Supplementary Fig. 1, http://links.lww.com/MD/D68).[12,13,21–33]

3.2. Study characteristics and clinical outcomes

Of the 985 total patients in the studies analyzed, 528 were treated with RF neurotomy. The total number of participants in the analyzed studies ranged from 6 to 82 in the RF neurotomy and control groups, respectively. The patients' ages were similar in the RF neurotomy group (range: 41years to 65 years) and the control group (range: 41 years to 64 years) (Table 1). The percentage of males ranged from 12% to 72% in the RF neurotomy group and from 13% to 74% in the control group. Most studies reported chronic lumbar facet joint pain[21–26,29,30,33] and 5 reported sacroiliac joint pain.[12,13,27,28,31]

Among the 15 studies examined, all were RCTs; 8 involved conventional RF facet neurotomy,[21–24,26] 4 involved percutaneous RF heat lesion,[25,27,29,32] 2 involved cooled RF sacroiliac joint lateral branch neurotomy,[12,13] and 1 involved palisade sacroiliac joint FR neurotomy (Table 1).[31]

3.3. Primary outcome measures

The results of all primary outcome measures (ODI scores, measurement for pain, and QoL) are shown in Supplementary Table 2, http://links.lww.com/MD/D68.

3.3.1. *ODI score.* Six studies were included in analysis of ODI scores[12,13,21,23,32,33], and 9 studies were excluded because they did not report ODI scores. There was no significant heterogeneity when data from the remaining 6 studies were pooled (heterogeneity test: $Q=9.0$; df=5; $P=.110$; $I^2=44.3\%$). The RF neurotomy group achieved a significantly greater improvement in ODI scores compared with controls who received a sham or medical treatment (pooled difference in means=–5.64; 95% confidence interval [CI]: –9.19 to –2.10; $P=.002$) (Fig. 1).

Table 2

Subgroup analysis for Oswestry Disability Index.

	Number of study	Heterogeneity: Q value	I-square	Effect size: Difference in means (95% CI)	*P* value
Group by comparison					
RF neurotomy vs sham	5	9.1	55.9%	−5.67 (−9.68, −1.66)	.006
RF neurotomy vs medical treatment	1	0	0%	−7.10 (−16.99, 2.79)	.159
Group by type of pain					
Sacroiliac joint	2	1.8	44.8%	−8.91 (−16.44, −1.38)	.020
Lumbar facet joint	3	3.8	47.4%	−6.08 (−11.89, −0.27)	.040
Group by follow-up duration					
1 month	1	0	0%	−0.60 (−5.43, 4.23)	.808
2 months	1	0	0%	−12.76 (−22.68, −2.84)	.012
3 months	3	5.1	60.7%	−6.03 (−12.28, 0.23)	.059
6 months	2	0.6	0%	−3.31 (−6.40, −0.22)	.036
1 year	1	0	0%	−4.70 (−8.16, −1.24)	.008

CI=confidence interval; RF=radiofrequency.

Study name	Statistics for each study: Difference in means	Lower limit	Upper limit	p-Value	Relative weight
Mehta (2018)	-3.90	-5.63	-2.17	0.000	5.45
Moussa (2016)	-0.75	-1.14	-0.36	0.000	8.61
van Tilburg (2016a)	-0.30	-1.12	0.52	0.473	7.79
van Tilburg (2016b)	0.00	-0.83	0.83	1.000	7.76
Zhou (2016)	-4.20	-4.78	-3.62	0.000	8.30
Zheng (2014)	-2.20	-3.06	-1.34	0.000	7.69
Lakemeier (2013)	-0.30	-1.41	0.81	0.598	7.05
Civelek (2012)	-1.60	-1.76	-1.44	0.000	8.84
Patel (2012)	-1.60	-3.12	-0.08	0.039	6.00
Cohen (2008)	-3.20	-4.68	-1.72	0.000	6.09
Nath (2008)	-1.40	-2.93	0.13	0.072	5.98
Tekin (2007)	-0.50	-1.37	0.37	0.258	7.68
Leclaire (2001)	0.77	-0.46	2.00	0.218	6.76
van Kleef (1999)	-2.00	-3.53	-0.47	0.010	5.98
Pooled estimate	-1.46	-2.11	-0.81	0.000	

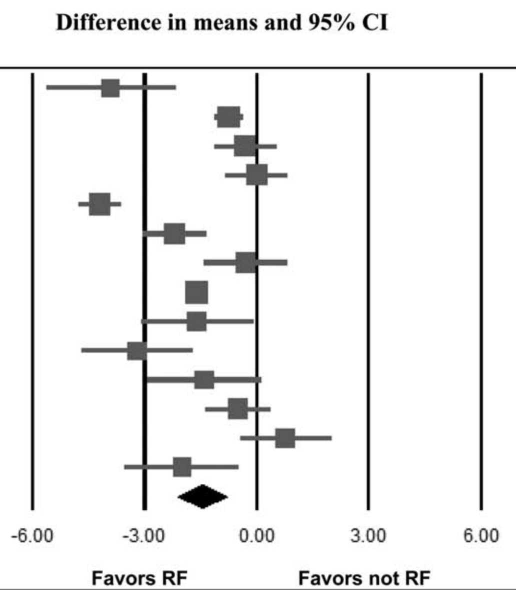


Figure 2. Forest plots showing the meta-analysis results for painfor all studies (RF vs non-RF).

Five of the previously mentioned studies[12,13,23,32,33] compared RF neurotomy vs sham treatment and were further analyzed. There was heterogeneity when data from the 5 studies were pooled (heterogeneity test: $Q=9.1$; $I^2=55.9\%$). The RF neurotomy group achieved a significantly greater improvement in ODI scores compared with the sham treatment group (pooled difference in means =–5.67; 95% CI: –9.68 to –1.66; $P=.006$) (Table 2).

In a subgroup analysis of sacroiliac joint pain, the RF neurotomy group achieved a significantly greater improvement in ODI scores compared with the control group (pooled difference in means =–8.91; 95% CI: –16.44 to –1.38; $P=.020$). The RF neurotomy group achieved a significantly greater improvement in ODI scores compared with the control group in the subgroup of patients with lumbar facet joint pain (pooled difference in means =–6.08; 95% CI: –11.89 to –0.27; $P=.040$). Analyses stratified by follow-up duration showed a consistent direction of association between RF treatment and ODI score. The ODI score improved after 2 months of follow up (pooled difference in mean ranged from −12.76 to −3.31), although the results at 3 months did not reach statistical significance (Table 2).

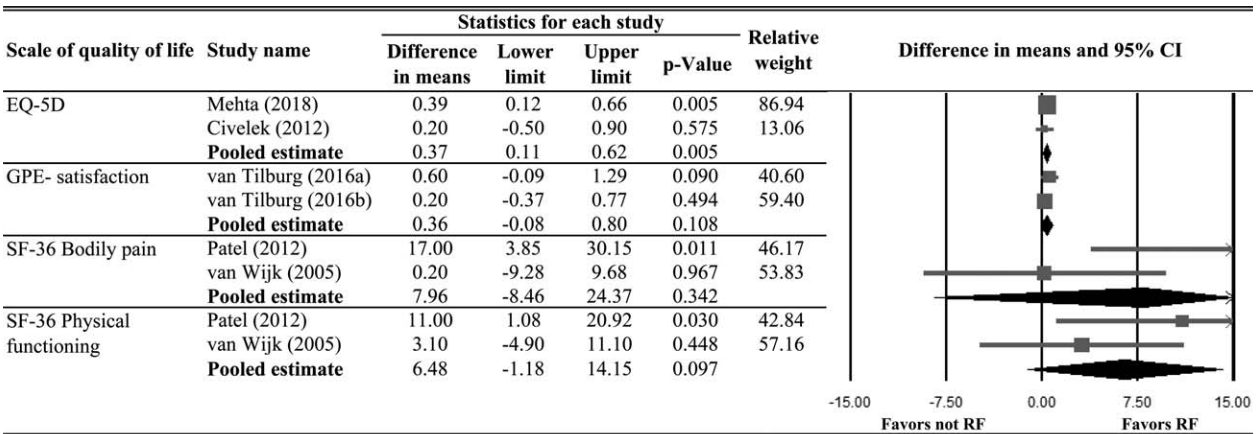
3.3.2. Pain. Fourteen studies[12,13,21–23,25–33] were included in the analysis of pain, and one study[24] was excluded because the results for pain was not reported. There was significant heterogeneity when data from the remaining 14 studies were pooled (heterogeneity test: $Q=157.4$; df=13; $P<.001$; $I^2=91.7\%$). The RF neurotomy group achieved significantly greater improvement in pain scores compared with controls who received sham treatment or medical treatment (pooled difference in means =–1.46; 95% CI: –2.11 to –0.81; $P<.001$) (Fig. 2).

Table 3

Subgroup analysis for pain.

Follow-up duration	Number of study	Heterogeneity: Q value	I-square	Effect size: Difference in means (95% CI)	*P* value
Group by comparison					
RF neurotomy vs sham	10	38.1	76.4%	−1.09 (−1.75, −0.43)	.001
RF neurotomy vs medical treatment	4	79.5	96.2%	−2.11 (−3.59, −0.64)	.005
Group by type of pain					
Sacroiliac joint	5	22.6	82.3%	−2.13 (−3.4, −0.87)	.001
Lumbar facet joint	9	134.4	94.0%	−1.14 (−1.97, −0.31)	.007
Group by follow-up duration					
1 month	4	32.6	90.8%	−0.79 (−2.07, 0.50)	.229
2 months	1	0	0%	−2.00 (−3.53, −0.47)	.010
3 months	6	36.4	86.3%	−1.71 (−2.84, −0.58)	.003
6 months	7	206.6	97.1%	−2.12 (−3.29, −0.96)	<.001
1 year	3	322.4	99.4%	−2.82 (−5.27, −0.37)	.024
2 years	1	0	0%	−3.60 (−3.76, −3.44)	<.001
3 years	1	0	0%	−3.70 (−3.98, −3.42)	.003

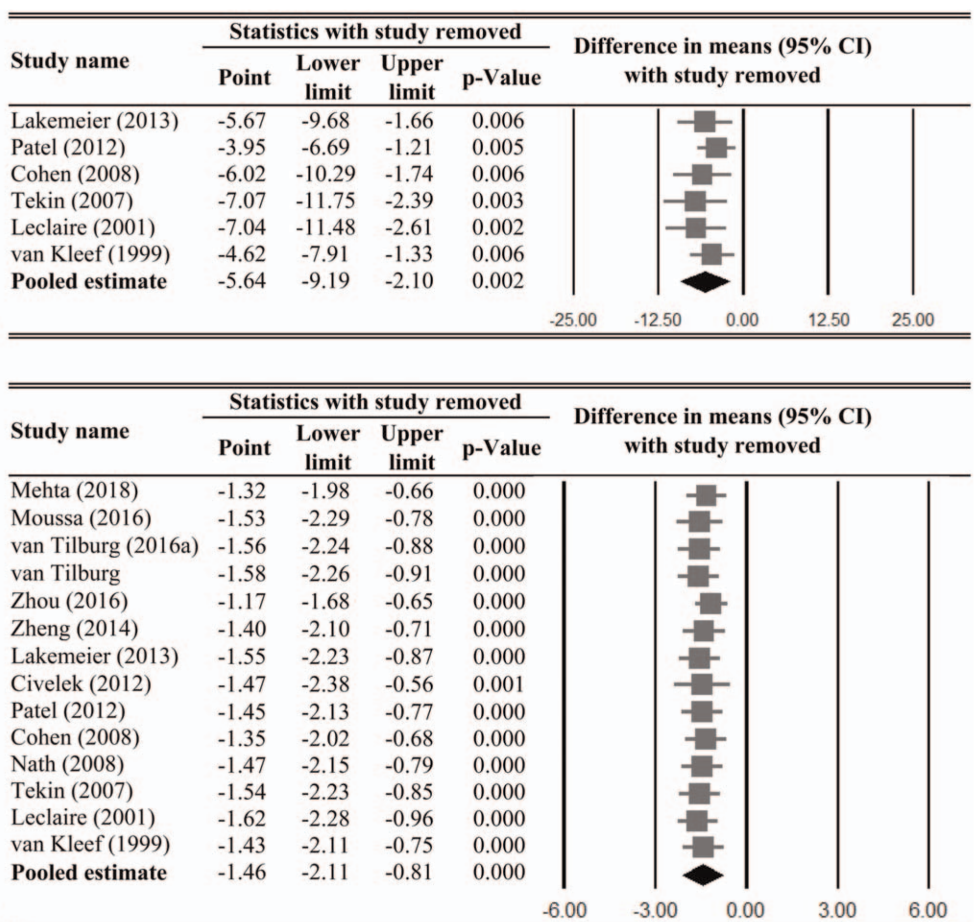
CI = confidence interval; RF = radiofrequency.



Scale of quality of life	Study name	Statistics for each study: Difference in means	Lower limit	Upper limit	p-Value	Relative weight
EQ-5D	Mehta (2018)	0.39	0.12	0.66	0.005	86.94
	Civelek (2012)	0.20	-0.50	0.90	0.575	13.06
	Pooled estimate	0.37	0.11	0.62	0.005	
GPE- satisfaction	van Tilburg (2016a)	0.60	-0.09	1.29	0.090	40.60
	van Tilburg (2016b)	0.20	-0.37	0.77	0.494	59.40
	Pooled estimate	0.36	-0.08	0.80	0.108	
SF-36 Bodily pain	Patel (2012)	17.00	3.85	30.15	0.011	46.17
	van Wijk (2005)	0.20	-9.28	9.68	0.967	53.83
	Pooled estimate	7.96	-8.46	24.37	0.342	
SF-36 Physical functioning	Patel (2012)	11.00	1.08	20.92	0.030	42.84
	van Wijk (2005)	3.10	-4.90	11.10	0.448	57.16
	Pooled estimate	6.48	-1.18	14.15	0.097	

Figure 3. Forest plots showing the meta-analysis results for quality of life for all studies (RF vs non-RF).

Four studies[21,22,30,31] compared the effectiveness of RF neurotomy vs medical treatment and reported scores for pain. There was heterogeneity in included studies (heterogeneity test: $Q=79.5$; $I^2=96.2\%$). Significant improvement in pain was noted between the 2 treatments (i.e., between RF neurotomy and medical treatment [pooled difference in means =–2.11, 95% CI: –3.59 to –0.64; $P=.005$]). In addition, there were 10 studies comparing RF neurotomy and sham treatment.[12,13,23,25–29,32,33] Heterogeneity was observed in the10 studies (heterogeneity test: $Q=38.1$; $I^2=70.5\%$). The RF neurotomy group achieved a significantly greater improvement in pain scores compared with the sham group (pooled difference in



A

Study name	Statistics with study removed: Point	Lower limit	Upper limit	p-Value
Lakemeier (2013)	-5.67	-9.68	-1.66	0.006
Patel (2012)	-3.95	-6.69	-1.21	0.005
Cohen (2008)	-6.02	-10.29	-1.74	0.006
Tekin (2007)	-7.07	-11.75	-2.39	0.003
Leclaire (2001)	-7.04	-11.48	-2.61	0.002
van Kleef (1999)	-4.62	-7.91	-1.33	0.006
Pooled estimate	-5.64	-9.19	-2.10	0.002

B

Study name	Statistics with study removed: Point	Lower limit	Upper limit	p-Value
Mehta (2018)	-1.32	-1.98	-0.66	0.000
Moussa (2016)	-1.53	-2.29	-0.78	0.000
van Tilburg (2016a)	-1.56	-2.24	-0.88	0.000
van Tilburg	-1.58	-2.26	-0.91	0.000
Zhou (2016)	-1.17	-1.68	-0.65	0.000
Zheng (2014)	-1.40	-2.10	-0.71	0.000
Lakemeier (2013)	-1.55	-2.23	-0.87	0.000
Civelek (2012)	-1.47	-2.38	-0.56	0.001
Patel (2012)	-1.45	-2.13	-0.77	0.000
Cohen (2008)	-1.35	-2.02	-0.68	0.000
Nath (2008)	-1.47	-2.15	-0.79	0.000
Tekin (2007)	-1.54	-2.23	-0.85	0.000
Leclaire (2001)	-1.62	-2.28	-0.96	0.000
van Kleef (1999)	-1.43	-2.11	-0.75	0.000
Pooled estimate	-1.46	-2.11	-0.81	0.000

Figure 4. Results of sensitivity analysis used to examine the influence of individual studies on pooled estimates (determined using the leave-one-out approach) for (A) ODI; (B) pain. ODI=Oswestry Disability Index.

means = −1.09; 95% CI: −1.75 to −0.43; P = .001). Furthermore, both subgroup analyses (sacroiliac joint and lumbar facet joint) showed significant improvement in pain between the 2 groups (pooled difference in means = −2.13; 95% CI: −3.40 to −0.87; P = .001 for sacroiliac joint and pooled difference in means = −1.14; 95% CI: −1.97 to −0.31; P = .007 for lumbar facet joint). When subgroup analysis was performed according to follow-up duration, prominent improvement in pain was noted after two months (pooled difference in means ranged from −3.70 to −1.71) (Table 3).

3.3.3. QoL. A total of 6 studies were included in the meta-analysis for QoL. Two studies reported results for EQ-5D,[22,28] another 2 reported GPE-satisfaction,[25,27] and the remaining 2 reported SF-36.[12,24] Except for SF-36 bodily pain scale, there was no significant heterogeneity (EQ-5D: Q = 0.25, P = .619, I^2 = 0%; GPE: Q = 0.76, P = .384, I^2 = 0%; SF-36 bodily pain: Q = 4.12, P = .042, I^2 = 75.8%; SF-36 physical functioning: Q = 1.48, P = .224, I^2 = 32.3%). The results showed significant improvement in QoL measured by EQ-5D in the RF neurotomy group compared to the non-RF group (pooled difference in means = 0.37, 95% CI = 0.11 to 0.62, P = .005). Although improvements were also found for the other three scales of QoL, the results did not reach statistical significance (Fig. 3).

3.4. Sensitivity analysis

The results of the sensitivity assessment using the leave-one-out approach are summarized in Figure 4. When comparing RF neurotomy and all other treatments, the direction and magnitude of pooled estimates did not vary considerably in terms of ODI scores (Fig. 4A) and scores for pain (Fig. 4B), indicating that the meta-analysis had good reliability in terms of the ODI score and the VAS pain score. Since only two studies were included for each scale of QoL, sensitivity analyses were not performed for QoL.

3.5. Quality assessment

An assessment of the quality of each study included in the current analysis was performed and is summarized in Figure 5. For each trial, the risk of bias is detailed in the risk-of-bias summary (Fig. 5A). In addition, an overall assessment of risk of bias was performed (Fig. 5B). Some of the studies were limited by the lack of blinding of patients and/or physicians. Overall, the most prevalent issue in the included studies was a lack of information regarding the intention-to-treat analysis (not stated in 13 of the included trials). Three studies appeared to have unclear risk of bias regarding allocation concealment, but overall the studies seemed to have a low level of bias (Fig. 5A).

3.6. Publication bias

Publication bias was assessed for pain score and is presented in Figure 6. The results showed no publication bias for pain (t = 0.211; df = 12; P = .836). Funnel plots were not shown for ODI score and QoL because such analysis requires the inclusion of more than 10 studies in order to detect funnel plot asymmetry.[34]

4. Discussion

Based on the results of the current meta-analysis, specifically the ODI scores, the use of RF neurotomy appeared to improve patients' functional outcomes compared with other conservative

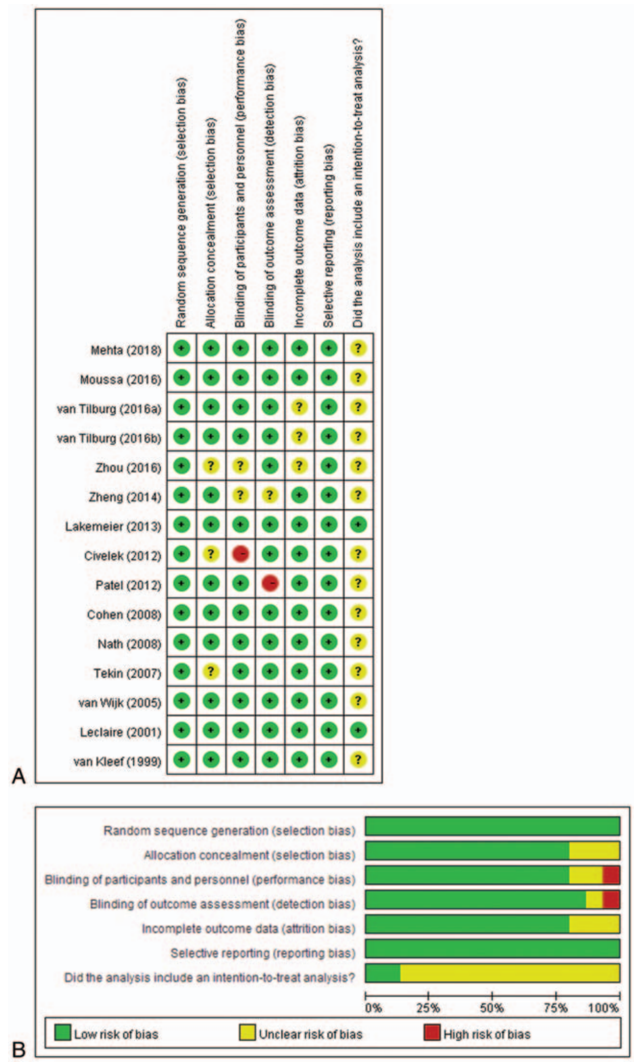


Figure 5. The quality assessment for each included study summarized in (A) the risk-of-bias summary or (B) presented as percentages across all included studies in the risk-of-bias graph using the Cochrane Risk of Bias Tool.

nonsurgical treatments. Pain scores also improved following RF neurotomy compared with conservative management, although a 1.46-point difference on a10-point scale of improvement between groups represented a rather small effect. Although QoL as measured by EQ-5D significantly improved in the RF neurotomy group as compared to the non-RF group, only 2 studies were included. In subgroup analyses, patients who received RF neurotomy had a significantly greater improvement in ODI scores compared with those with sham treatment. Patients treated with RF achieved significantly greater improvement in pain scores compared with controls who received sham treatment or medical treatment. In the analyses stratified by follow-up duration, the ODI score and pain score were improved after 2 months of follow up.

A previous systematic review showed that RF neurotomy was effective to treat lumbar facet joint and sacroiliac joint pain.[16] However, a recent systematic review comparing RF neurotomy and sham procedure in treating chronic LBP caused by lumbar facet joints showed conflicting evidence at an intermediate 3- to

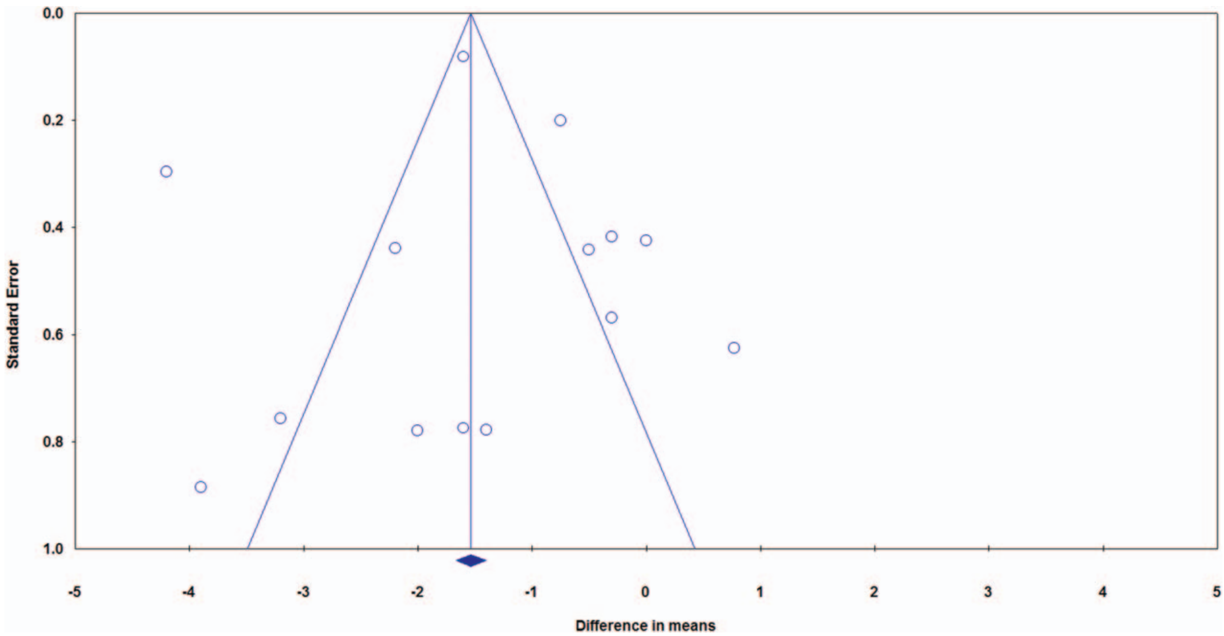


Figure 6. Funnel plot for pain. Blank circles represent observed studies. Solid rhombus represents observed combined effect size.

6-month stage among included studies.[17] Neither of the 2 studies performed meta-analysis. A recent meta-analysis compared the precise effects of RF neurotomy with control treatments (sham or epidural block) in patients with LBP originating from the facet joints. Conventional RF neurotomy significantly reduced LBP originating from the facet joints in patients who had the best response to diagnostic block over the first 12 months when compared with control treatments.[35] Another systematic review and meta-analysis also favored RF neurotomy for pain control in the treatment of facet joint-related LBP.[36] Therefore, previous analyses and reviews support the current findings of pain improvement in chronic LBP after RF neurotomy when compared with conservative treatments.[16,17,35,36] In addition to pain relief, the current study also showed that RF neurotomy improved functional outcomes in patients with lumbar facet joint and sacroiliac joint pain, compared with sham procedure or steroid injection. Furthermore, QoL was also analyzed. However, only 2 studies were included for each scale, despite a significant improvement in EQ-5D in the RF neurotomy group compared to the non-RF group. More studies are needed to confirm the results in terms of QoL. The current findings add to current knowledge and may help in clinical evaluation of RF neurotomy to treat facet joint pain.

RCTs included in our meta-analysis evaluated the use of conventional RF facet neurotomy for the relief of lumbar facet pain,[21–24,26,30,33] but only 2 RCTs involved cooled RF sacroiliac joint lateral branch neurotomy.[12,13] Although the results of multiple retrospective studies have been reported, only 8 were RCTs that evaluated the effect of conventional RF facet neurotomy for treatment of chronic LBP after 2000,[21–24,26,28,30,33] and most studies showed better efficacy of conventional RF facet neurotomy compared to nonsurgical treatment. Only one study showed similar pain relief and functional improvement for steroid injections and conventional RF facet neurotomy.[21] Despite the small number of patients evaluated in these studies, the several RCTs demonstrated the efficacy of conventional RF facet neurotomy compared with conservative nonsurgical treatment.

Results have varied between trials examining RF facet neurotomy for the relief of lumbar facet pain. For example, Guerts et al conducted 2 studies and reported conflicting results.[37,38] Their first study found moderate evidence that conventional RF facet neurotomy was more effective for chronic LBP compared with placebo.[37] However, results of their second study failed to show a significant difference between patients treated with conventional RF facet neurotomy of the dorsal root ganglia for chronic lumbosacral radicular pain and those treated with conservative, nonsurgical approaches.[38] Two other studies that analyzed the efficacy of cooled sacroiliac joint RF neurotomy found that the intervention was efficacious and long-lasting.[12,13] The differences in these results are likely due to the different mechanisms of action of the 3 types of RF neurotomy. Conventional RF neurotomy uses heat to produce thermocoagulation of the nerve. Cooled RF produces larger lesions, making it more likely that the nociceptive input from the sacroiliac joints is interrupted,[11,12] and thus cooled RF is more effective for pain relief and improved function.

4.1. Study limitations

Our study has several limitations worth noting. First, this systematic review lacked a pre-specified protocol and its preliminary registration; thus, biased post-hoc decisions during review of the methods may occur. Second, the current analysis included a small number of studies measuring QoL. In addition, heterogeneity was noted among both RF neurotomy and other conservative nonsurgical treatments. For example, cooled RF was used in certain studies,[12,13] whereas others[21,22,24] used conventional RF thermocoagulation. In addition, 3 groups[21,22,30] compared RF neurotomy and steroid injections, and one study compared palisade sacroiliac joint RF neurotomy and celecoxib.[31] Researchers in the11 remaining studies[12,13,23–

[29,32,33] used sham neurotomy as the control. We performed additional subgroup analyses using similarly designed studies (such as separate analyses of studies that used RF vs sham treatment and studies that used RF vs steroid injections/celecoxib). Although our findings depended on the selection criteria and the designs of included studies, our criteria were not unreasonably strict. Third, some of the 2-arm studies included in the meta-analysis lacked blinding (to patients and/or physicians).[13,22] Finally, others may have reported inflated results in their neurotomy groups due to pre-emptive joint injections of corticosteroids or local anesthetics; therefore, future studies using larger cohorts will be needed to confirm our results.

5. Conclusion

Patients treated with RF neurotomy for chronic lumbar and sacroiliac joint pain had significantly greater improvement in pain and functional outcomes compared with those who received conservative treatment or sham therapy. Larger, more directly comparable studies will be needed to confirm the current findings.

Author contributions

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Writing – review & editing: Chia-Hsien Chen, Pei-Wei Weng, Yueh-Feng Chiang, Chang-Jung Chiang.

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