Retrospective Study

Extended Relief at All Spinal Regions and Lower Lumbar VAS: Endoscopic Rhizotomy vs. Radiofrequency Ablation: A Retrospective Cohort Study

Ramy Gadalla, BSc[1], Mani Nathan Nair, MD[2], Christopher Spevak, MD[3], Georgia Wang, BSc[1], Debraj Mukherjee, MD[4], Guillermo Ernesto Corredor Alonso, MD[5], Hasan Syed, MD[6], Ehsan Dowlati, MD[7], Benjamin Ramsey, MD[8], Mark Habib, BSc[1], and Baher Yanni, MD[9]

From: [1]Georgetown University School of Medicine, Washington, DC, USA; [2]Department of Neurosurgery, Georgetown University School of Medicine, Washington, DC, USA; [3]Department of Anesthesia, Georgetown University School of Medicine, Washington, DC, USA; [4]Department of Neurosurgery, Johns Hopkins, Baltimore, MD, USA; [5]AstraZeneca Computational Pathology, Munich, Germany; [6]Children's National, Washington DC, USA; [7]University of Michigan, Ann Arbor, MI, USA; [8]Wake Forest University Medical Center, Winston-Salem, NC, USA; [9]Spine Institute of North America, East Windsor, NJ, USA

Address Correspondence:
Ramy Gadalla, BSc
Georgetown University School of Medicine, Neurosurgery
3800 Reservoir Rd. NW
Washington, DC 20001
E-mail: rsg78@georgetown.edu

Disclaimer: There was no external funding in the preparation of this article.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article. Furthermore, the authors have not received any other reimbursement or honorarium except for BY, who received an honorarium for a 2022 Elliquence Cadaver Course. The authors are not affiliated

Background: Facet joint syndrome accounts for many patients' chronic neck and low back pain. Current interventional treatment options for these conditions include radiofrequency ablation (RFA) and endoscopic rhizotomy (ER), which target the medial branch of the dorsal ramus innervating the facet joint capsule. RFA is a percutaneous procedure in which radiofrequency waves ablate the medial branch. ER, a newer and more invasive procedure, is typically reserved for patients who have not responded to RFA. This retrospective cohort study aims to compare the postoperative pain level (VAS score), duration of pain relief, and opioid intake among patients who have received ER to those of patients who have received RFA. The results of these operations at all 3 spinal levels will be examined.

Objectives: To evaluate the longevity and quality of pain relief status post RFA versus ER for facet joint syndrome.

Study Design: A retrospective cohort study that includes patients treated with sequentially with RFA and then ER. The study analyzed the endpoint after each procedure for each spinal region.

Setting: Three urban neuro-spine centers.

Methods: The study utilized the Strengthening the Reporting of Observational Studies in Epidemiology Analysis (STROBE) initiative. Patients with positive diagnostic medial branch blocks (80% pain relief) obtained RFA and ER, in sequence. The region of procedure (cervical, thoracic, or lumbar), morphine milligram equivalent (MME) requirements, VAS pain scores before and after the procedure, and duration of relief were collected from the electronic medical records. Patient follow-ups were conducted at 3 months, 6 months, 9 months, 12 months, and after 12 months.

Results: Among the 234 patients who underwent 511 RFAs and 386 ERs, ER was associated with significantly better efficacy than RFA in VAS scores ($P = 0.001$), opioid consumption ($P = 0.0442$), and duration of pain relief ($P < 0.0001$), with all spinal levels analyzed aggregately. However, with each spinal region analyzed separately, ER was associated with significantly lower VAS scores only in the lumbar spine ($P < 0.0001$) while the longer duration of relief persisted across all regions ($P < 0.05$).

Limitations: The study design was retrospective and nonrandomized. The study also did not utilize functional scales, e.g., the Oswestry Disability Index. Finally, ER is not available to the public.

Conclusion: Both procedures decrease pain levels and opioid consumption significantly. ER is associated with lower pain levels, lower opioid consumption, and a longer duration of pain relief than RFA in the aggregate data. However, when each spinal region is re-analyzed separately, ER results in significantly lower pain levels only in the lumbar spine. Nonetheless, ER continues to provide a longer relief duration than does RFA in all spinal regions. Deploying ER sooner in patients

in any manner with RFA or ER. However, CS and BY are practicing interventional pain physicians.

Article received: 10-06-2024
Revised article received: 03-09-2025
Accepted for publication: 03-24-2025

Free full article: www.painphysicianjournal.com

with facet joint pain may be more beneficial than performing RFA and waiting for pain symptoms to recur.

Key words: Endoscopic rhizotomy (ER), Radiofrequency Ablation (RFA), medial branch nerve ablation, facet joint syndrome, opioid intake, morphine milligram equivalents (MME), Visual analog score (VAS), Pain relief, duration of relief

Pain Physician 2025: 28:E445-E456

Facet joints are part of the 3-joint complex of adjacent vertebrae, comprising the 2 zygophageal joints and intervertebral disk space, where degeneration in one leads to accelerated degeneration in others (1,2). Facet joint syndrome, characterized by the degeneration of the facet joint capsule and the subsequent transmission of noxious stimuli by the dorsal ramus, is a common spinal pathology, accounting for a substantial portion of patients with spinal pain (3). Clinically, this condition is characterized by dull, aching axial pain in the "facet joint pain pattern" in the neck, shoulders, hips, and thighs, exacerbated by cervical or lumbar extension (4-6). However, the clinical symptoms do not correlate with radiologic changes (7,8).

The dorsal rami of the spinal cord divide into medial, intermediate, and lateral branches. The medial nerve supplies the facet joint at the same and superior levels (Fig. 1a). The intermediate and lateral nerves are more superficial and descend laterally and caudally, supplying the back muscles. Medial branches at 2 levels (above and below) innervate each facet joint (Fig. 1B) (7). In cases of facet joint syndrome, these nerves are impinged upon by the bony protuberances, causing pain.

While intervertebral disc herniation is typically considered a leading cause of back pain, other structures may also contribute to it (including pathology of the muscles, ligaments, dura, and sacroiliac joints) (9). Facet joint syndrome is also recognized as a leading spinal pathology. Facet joint syndrome is comorbid with trauma (e.g., whiplash injury), failed back surgeries, degenerative disease (e.g., osteoarthritis with facet hypertrophy and vacuum phenomenon), debility, fracture (e.g., spondylolisthesis), and excessive biomechanical stress secondary to poor posture (7).

Spinal pain is the most common cause of disability in the USA, with a lifetime prevalence of 54 to 80% (4,10). Specifically, the prevalence of facet joint pain in the cervical, thoracic, and lumbar spine is 49.3%, 34-48%, 16-41%, respectively (12,19). At the individual level, spinal pain has severe psychosocial sequelae, including depression, dependence on others in performing activities of daily living, reduced productivity, and loss of income (11). Spinal pain also carries enormous health care costs due to unnecessary surgery, imaging overuse, and time off from work. In addition, at a population level, spinal pain has significant implications on expenditure. In 2016, an estimated $134.5 billion was spent on low back and neck pain, accounting for the highest public insurance spending (33.7%) (10). Furthermore, health care costs caused by facet joint interventions increased by 79% from 2009 to 2018 in Medicare populations (10).

Current surgical treatment options for facet joint syndrome include the medial branch block (MBB), needle-radiofrequency ablation (RFA), and endoscopic rhizotomy (ER) (8). The MBB is a standard procedure used to diagnose and manage facetogenic pain. If a patient's history and physical examination reveal that the facet joint may be the primary pain source for that patient, an MBB is diagnostic (12). The MBB procedure involves targeting the medial branch of the dorsal ramus of a spinal nerve and infiltrating the local tissue with a local anesthetic. Since the dorsal rami exit neuroforamina above and below the innervated facet joint capsules (Fig. 1B), 2 levels are targeted at a minimum. If the patient reports at least 80% relief of symptoms after 2 MBBs, the diagnosis of facet joint syndrome is supported, and the local coverage determinations prefer the progression to percutaneous needle radiofrequency ablation (RFA) (8,12-14). RFA is a medical procedure intended to destroy tissue with the use of current-generated heat (15). Image-guided RFA can be performed percutaneously with a similar technique to the MBB that uses a cannula and radiofrequency generator instead (16,17). Ablating the medial branch nerve stops the facet joint (i.e., the zygapophyseal joint) from

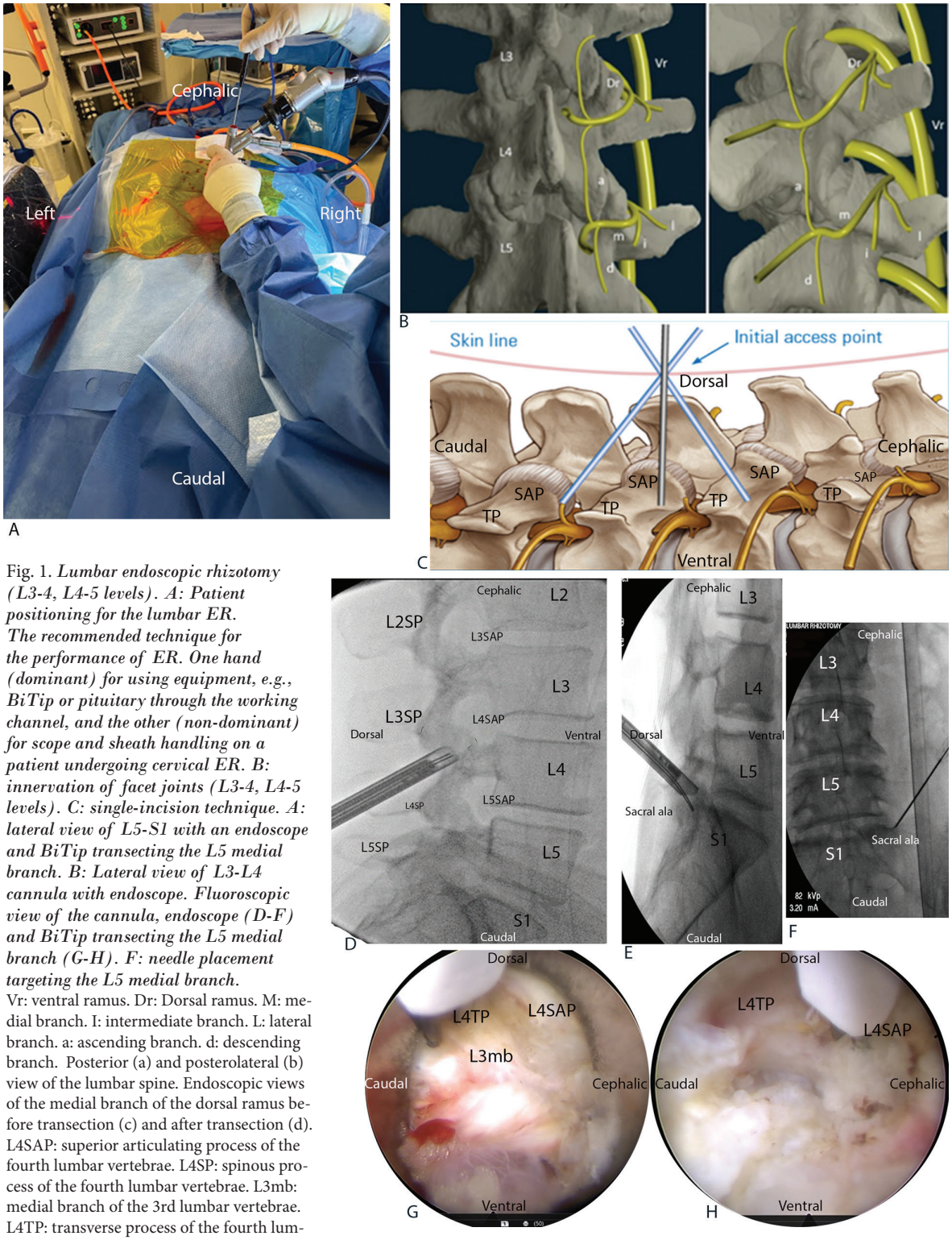

Fig. 1. *Lumbar endoscopic rhizotomy (L3-4, L4-5 levels). A: Patient positioning for the lumbar ER. The recommended technique for the performance of ER. One hand (dominant) for using equipment, e.g., BiTip or pituitary through the working channel, and the other (non-dominant) for scope and sheath handling on a patient undergoing cervical ER. B: innervation of facet joints (L3-4, L4-5 levels). C: single-incision technique. A: lateral view of L5-S1 with an endoscope and BiTip transecting the L5 medial branch. B: Lateral view of L3-L4 cannula with endoscope. Fluoroscopic view of the cannula, endoscope (D-F) and BiTip transecting the L5 medial branch (G-H). F: needle placement targeting the L5 medial branch.*
Vr: ventral ramus. Dr: Dorsal ramus. M: medial branch. I: intermediate branch. L: lateral branch. a: ascending branch. d: descending branch. Posterior (a) and posterolateral (b) view of the lumbar spine. Endoscopic views of the medial branch of the dorsal ramus before transection (c) and after transection (d). L4SAP: superior articulating process of the fourth lumbar vertebrae. L4SP: spinous process of the fourth lumbar vertebrae. L3mb: medial branch of the 3rd lumbar vertebrae. L4TP: transverse process of the fourth lumbar vertebrae. (Fig. 1b used with permission from Perolat et al.)

transmitting pain signals to the brain, reducing low back pain. Several controlled studies show that RFA decreases pain scores on the visual analog scale (VAS) (4,17,18). While complications of RFA are rare, at a risk of 1%, its potential side effects include both localized and neuropathic pain after the procedure (4,19). Although 100% of patients typically achieve initial pain relief after RFA, irrespective of region, 31%, 18%, and 26% report recurrence of pain after an average of 6 months in the cervical, thoracic, and lumbar regions, respectively (20-30).

A newer technique to transect the medial branch nerve for facet joint syndrome is endoscopic rhizotomy ablation (ER) (31-33). In this procedure, physicians use an endoscope to visualize the affected facet joint's dorsal medial branch (DMB), which makes for precise ablation of the nerves surrounding the joint. Several studies demonstrate that endoscopic rhizotomy ablation decreases VAS scores for pain (31-33). However, a few direct comparative studies of ER and RFA exist, focusing on the lumbar spine, and in these, ER demonstrates more prolonged efficacy than RFA (23,31).

Consequently, we undertook this retrospective cohort study to compare patients' pain levels (as represented by VAS scores), duration of pain relief, and opioid intake following RFA and then ER. To our knowledge, only a few studies have compared the effects of ER to those of RFA on VAS scores and duration of pain relief for patients with chronic low back pain (23,31). However, our study provides a retrospective cohort study comparing ER and RFA on 3 outcomes (opioid use, duration of pain relief, and VAS score) at the L-spine, T-spine, and C-spine.

Methods

This study applied the Strengthening of the Reporting of Observational Studies in Epidemiology (STROBE) criteria.

Study Design

The study was approved by the local institutional ethics committee (IRB ID: STUDY00005877). Data were collected from an IRB-approved database covering procedures from July 2015 to March 2021. In this retrospective, nonrandomized cohort study, we included patients who had received RFA for facet joint syndrome and then proceeded to have ER due to the failure of the initial treatment. Patient outcomes after ER were compared to their earlier outcomes after RFA.

Setting

An outpatient interventional pain management clinic.

Patients

Inclusion Criteria

Patients had pain from lumbar spondylosis and facet arthrosis with poor results from RFA only. The inclusion criteria were as follows: (1) having chronic low back pain for a course longer than 3 months; (2) being nonresponsive to 2 months of conservative treatment, including physical therapy and NSAIDs; (3) seeing no change of lower limb sensation, movement, and reflexes as well as no bowel or bladder changes; (4) presenting hyperplasia of the zygapophysial joints, osteophytes of the articular process, narrowing of the joint space, osteoarthritis, asymmetry, or the intraarticular vacuum phenomenon as an imaging feature (recommended, not required); (5) having reported more than 80% pain relief after 2 MBBs with 0.25% bupivacaine at the transitional part of the superior articular process and transverse process within 3 months.

Exclusion Criteria

The exclusion criteria were as follows: (1) having fractures, tuberculosis, infections, or tumors; (2) having other causes of spinal pain, e.g., discogenic disease and sacroiliac joint disease; (3) being under 18 years of age; (4) or pregnant.

Sample Size

Two hundred thirty-four patients with chronic lumbar zygapophysial joint pain met the inclusion criteria and enrolled in our study (Fig. 2). The sample size is considered large when compared to previous studies on all the spinal regions (23,31-33).

Data Collection

We collected data from an IRB-approved database for procedures from July 2015 to March 2021. Two hundred thirty-four patients underwent the sequence of RFA followed by ER due to unsatisfactory relief from RFA or a duration of relief of < 6 months.

Assessment

All patients underwent a comprehensive history, a physical examination, and an evaluation of the results of prior procedures and investigations they had experienced. Examinations and evaluations of patients

were performed by one physician (BY). The charts were reviewed, and 234 patients who underwent at least one RFA followed by ER were identified.

Informed Consent

Informed consent was obtained after discussing risks, benefits, and alternative treatments with the patients.

Procedures

As a standard for both ER and RFA procedures in all regions, the patient was taken to the operating room and placed in a prone position, with a soft pillow set under the abdomen to maintain a position of kyphosis for the thoracic and lumbar regions. The surgeon stood on the side on which the procedure would be performed, and the fluoroscopy machine was on the opposite side (Fig. 1A and Figs. 3A-B). The procedure was performed while the patient was under sedation. In accordance with surgical protocol, a timeout was performed to confirm the correct patient and procedure information. After adequate sedation, the patient's neck or back was cleaned sterilely using ChloraPrep™ (Becton, Dickinson and Company) or Betadine® (iNova Pharmaceuticals) x3; sterile drapes and a C-arm cover were applied. A preoperative antibiotic was given. A 25-gauge 1.5-inch needle was used to place 0.5 mL of 1% lidocaine over the superomedial aspect of the transverse process, targeting the skin and subcutaneous tissue.

ER Surgical Method

Under fluoroscopic guidance, the corresponding vertebral pedicle and laminae were identified. A stab incision was made using a #11 blade. An obturator was inserted and directed at the point of intersection between the superior articular process and the transverse process of the corresponding vertebral level. Proper dilator placement was confirmed using fluoroscopy in the anteroposterior, oblique, and lateral views with a GE OEC 9900 Elite C-arm (General Electric Company) (Fig. 1 D-F). The working cannula was placed over the obturator. After the obturator was removed, the endoscope was then inserted through the working cannula. The soft tissue was fully ablated to expose the bone surface of the dorsal transverse process and the superior articular process. As an example, if the dorsal ramus of L5 was the target of interest, the probe was directed toward the point of intersection between the superior articular process and the alae sacralis. For C4-5, the dorsal ramus splits into superficial and deep

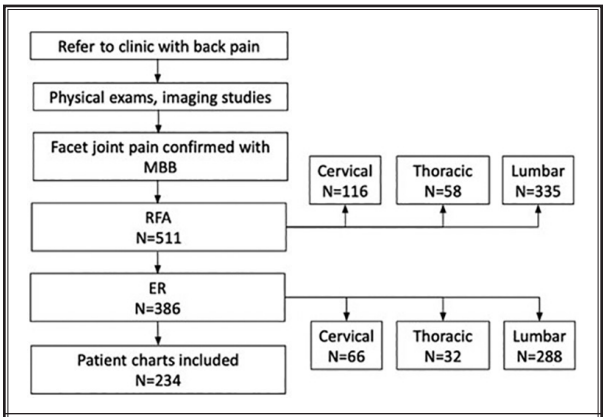

Fig. 2. *Flow chart of patients and procedures included in the study cohort. All patients underwent an MBB, RFA, and ER in sequence. MBB: medial branch block; RFA: radiofrequency ablation; ER: endoscopic rhizotomy.*

branches by tendinous fibers of semispinalis capitis, with the medial branch coursing deeper. If C3 was the target, the endoscope was directed at the dorsolateral aspect of maximum convexity between the transverse and superior articulating processes.

After the extraspinal nerve (medial branch) was directly visualized and identified, using a radiofrequency bipolar cutting tip, the dorsal medial branch was dissected and ablated (Fig. 1 G-H). The incision was then closed after removing the endoscope and working cannula using a 4.0 Monocryl™ suture (Ethicon, Inc.). The incision was covered with wound closure strips and sterile dressing.

RFA Surgical Method

For RFA, a 20-gauge 100 mm radiofrequency needle from Stryker with a 10 mm active Stryker tip was inserted anteriorly until bony contact was made at the junction of the transverse process with the superior articulating process under fluoroscopic guidance. Sensory (100 Hz) followed by motor (2 Hz) testing was performed at each target site in all our patients, and the stimulus threshold generally did not exceed 2V. A 0.75 cm probe was used in the cervical region, whereas in the thoracic and lumbar regions, a 100 mm probe was used. Correct positioning was verified with a lateral view. During the procedures, the surgical team ensured that there was no 1) paresthesia during placement of the needle, 2) aspiration of blood, or 3) lower extremity fasciculation with 5 volts at 2-Hz stimulation. Following the injection of 0.5 mL of 2% lidocaine at the level of interest, 2 RF lesions along the nerve path were performed at 80°C for 90 seconds at each site.

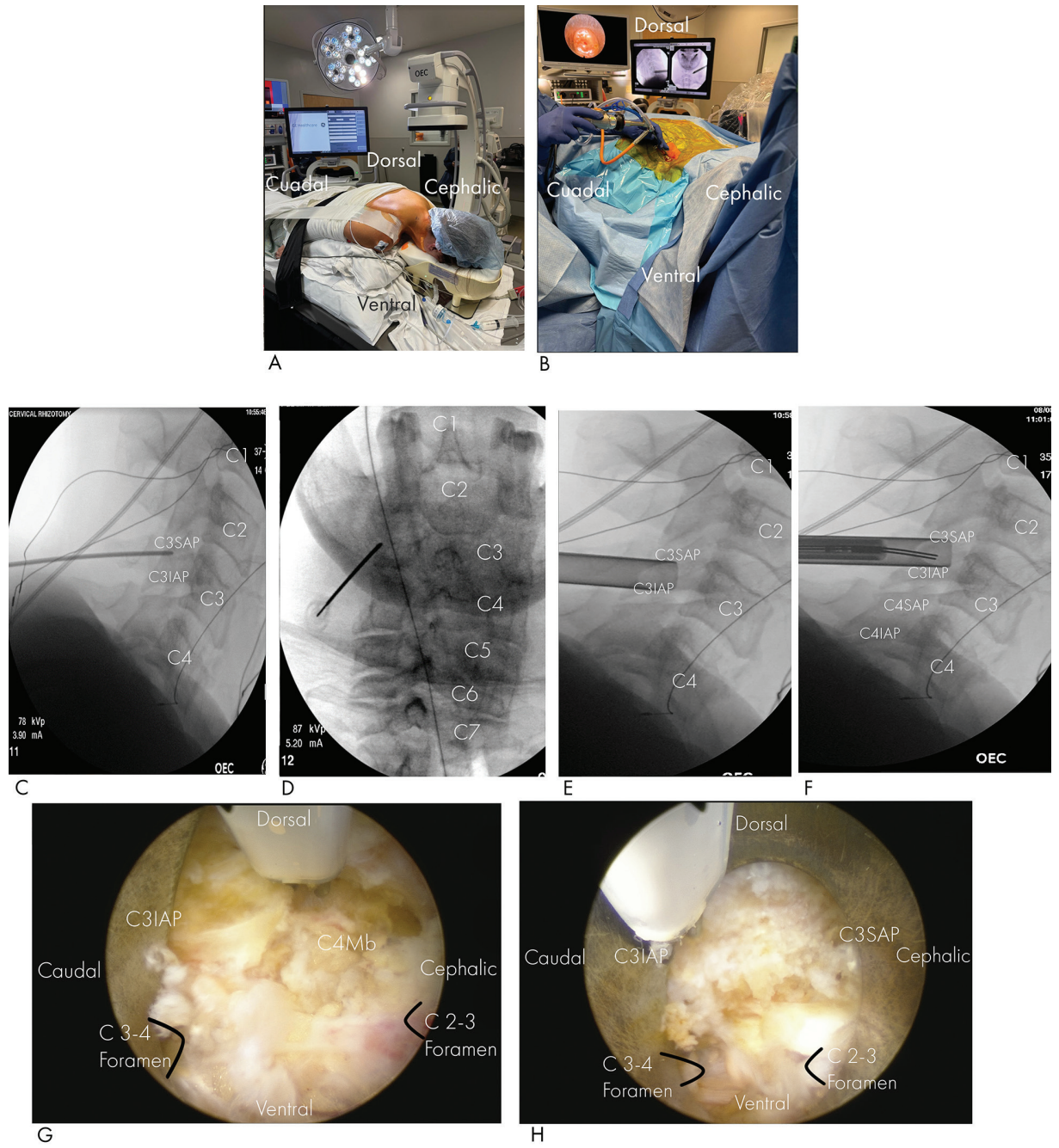

Fig. 3. *Cervical endoscopic rhizotomy. A-B: Patient positioning. The recommended technique for the performance of ER. One hand (dominant) for using equipment, e.g., BiTip or pituitary through the working channel, and the other (non-dominant) for scope and sheath handling on a patient undergoing cervical ER. C-F: Radiological lateral (C) and AP (D) views of the left C2-3 medial branch identified with the 18G spinal needle. Radiological lateral view of the cannula before inserting scope to identify the correct C2-3 medial branch level before (E) and after (F) inserting scope and the bipolar tip during dissection. G-H: lateral view of the BiTip transecting the C3 medial branch nerve. C3SAP: superior articulating process of the third cervical vertebrae. C3IAP: inferior articulating process of the third cervical vertebrae. C3Mb: medial branch of the third cervical vertebrae.*

Discharge and Postoperative Assessments

All patients were discharged 30 to 45 minutes after completion of the procedures. The patients were all contacted by a registered nurse within 24 hours after the block, and responses were recorded. All patients also returned for follow-up visits to assess pain relief and the total duration of ≥ 50% relief.

Variables and Data Measurement

Demographic data collected included age, gender, ethnicity, surgical history, and operative level. The VAS scores and morphine milligram equivalents (MMEs) for opioid consumption were collected before and after the procedures. Duration of relief was based on the last visit when the VAS started to increase or the patient complained of pain returning. The VAS included 10 ranks (1-3 = mild, 4-6 = moderate-severe, 7-9 = very severe, 10 = worst pain possible). Patients' pain scores were collected at 3 months, 6 months, 9 months, 12 months, and after 12 months to monitor the duration of pain relief.

Bias

This study was a retrospective evaluation using all consecutive patients. To mitigate bias, data were collected by a physician and clinical coordinator who was not involved in the provision or assessment of patients during the treatment period. There was no external funding.

Statistical Methods

Demographic data were compared using the Shapiro-Wilks and Chi-Square tests. Changes after RFA and ER were compared using paired t-tests. The VAS, change in VAS, MMEs, change in MMEs, and duration of pain relief between the RFA and ER were compared using the Wilcoxon ranked-sum test for the aggregate data and for each spinal region. The Kaplan-Meier analysis was used to compare the duration of relief experienced by RFA and ER patients. That analysis was rerun with the data split into cervical, thoracic, and lumbar sections. Data were analyzed using 2022 JMP Pro Version 17.

Sources of Funding

To reiterate, this study received no external funding.

Results

Table 1 displays the demographic and historical data of the patient cohort included in this retrospective study. A total of 234 patients underwent both procedures. Surgical history describes the patients' history of discectomy, fusion, or laminectomy. During the time frame studied, 511 RFA procedures and 386 ER procedures were performed in this cohort. Table 2 displays the mean preoperative MMEs and VAS scores of patients who underwent RFA and ER procedures.

VAS

When we compared the pre- and postoperative Likert scale pain levels for the RFA and ER patients, the paired t-test showed that the pain levels were significantly lower after each type of operation individually (Table 3, $P < 0.0001$). A pooled t-test on the difference between pre- versus post-VAS values, however, showed a significant difference between those associated with RFA and those associated with ER ($P < 0.0001$) (Table 2). When we compared the mean differences between RFA-associated scores and ER-associated scores by the L3-to-S1 level, using a pooled t-test, we also found significant differences ($P < 0.0001$) (Table 4). We did not find significant differences in the T1-T12 and C3-C7 ($P > 0.05$) using a pooled t-test.

Duration of Pain Relief

A t-test to determine if a significant difference existed between the period of relief for RFA and the period of relief for ER showed the mean for RFA was 178 days, compared to 336 days for ER ($P < 0.0001$) (Fig. 4). The significant difference persisted when we separated by L3 to S1 ($P < 0.0001$), T1-T12 ($P < 0.05$) and C3-C7 ($P < 0.05$) using a pooled t-test (Table 4).

Morphine Milligram Equivalents (MMEs)

We compared the pre- and postoperative MME levels, using a paired t-test for the ER and RFA ($P < 0.0001$) (Table 3). A pooled t-test to look at the difference between pre- and postoperative opioid consumption (pre-MME minus post-MME) for RFA and ER showed that the mean differences were significantly dissimilar to one another ($P < 0.05$). When opioid consumption was compared among the L3-to-S1, T1-T12, and C3-C7 levels, the MME level was not significant ($P > 0.05$).

Discussion

Multiple studies have shown that RFA has been effective for pain relief in most patients, with success rates differing depending on the location of the pain (19). For example, pain relief occurred in up to 75% of

Table 1. *Demographic data of patients analyzed for review. The Shapiro-Wilks test was performed to investigate the normality of the data distribution.*

	Mean (n = 234)		*P*-value
Age (years)	56		0.114
Gender (M/F)	115/118		
Race/ethnicity (W/AA/H/Other)	130/24/19/57		
BMI	28.34		0.0067*
Total number of MBB, RFA, and ER at different spinal levels	6		
Surgical history (Y/N)	106/127		
Spinal cord stimulator history (Y/N)	50/180		
	RFA	**ER**	
L/R/BL	254/229/27 (510)	197/178/11 (386)	
C3-C7/T1-T12/L3-S1	116/58/335 (509)	66/32/288 (386)	

W = White, AA = African American or Black, H = Hispanic or Latino, Other = Arab, Indian. *Indicates nonnormal distribution

Table 2. *Differential outcomes of the RFA and ER procedures. P-values generated by t-test (n > 30) or Wilcoxon ranked sum.*

	RFA (n = 511)	ER (n = 386)	*P*-value
Mean MME pre-op	32.77 +/- 45.14 (487)	34.73 +/- 49.48 (380)	0.933
Mean VAS pre-op	6.87 +/- 1.58 (489)	7.30 +/- 1.53 (386)	< 0.0001*
Mean MME S/P post-op	28.91 +/- 43.32 (487)	27.48 +/- 42.65 (375)	0.197
Mean VAS S/P post-op	2.97 +/- 2.11 (495)	2.93 +/- 1.97 (385)	0.787
Mean VAS difference (pre - post op)	3.84 +/- 2.01 (486)	4.38 +/- 2.09 (385)	0.001*
Mean MME difference (pre - post op)	4.45 +/- 15.02 (483)	7.31 +/- 27.84 (375)	0.0442*
Mean duration of pain relief (days)	178.68 +/- 246.46 (405)	336 +/- 305.95 (242)	< 0.0001*

Values are mean +/- SD. RFA = radiofrequency ablation, ER = endoscopic rhizotomy; MME = morphine milligram equivalent; L = left, R = right, BL = bilateral; C = cervical, T =thoracic, L = lumbar; VAS = visual analog scale. *Indicates statistical significance. Values < 0.05 reflect non-normal distribution.

Table 3. *Pre- and post-op VAS and MME by procedure.*

	Pre-Op	Post-Op	Difference in Means +/- SE	*P*-value
Mean MME ER (375)	34.79	27.48	7.31 +/- 1.44	< 0.0001*
Mean MME RFA (483)	32.93	28.48	4.45 +/- 0.68	< 0.0001*
Mean VAS ER (385)	7.30	2.93	4.37 +/- 0.11	< 0.0001*
Mean VAS RFA (486)	6.86	3.02	3.84 +/- 0.091	< 0.0001*

Standard error = SE.

patients with sacroiliac pain (34). However, one study conducted by Lord et al found that only 58% of the patients experienced pain relief (35). Studies on the use of ER for cervical and thoracic facet joint neck pain are even more limited. Li et al conducted a pilot study on endoscopic medial branch ablation for chronic pain in the cervical zygapophyseal joints. The researchers found that endoscopic ablation was a safe, accurate procedure that provided significant pain relief (32).

No prior studies, to our knowledge, compared opioid consumption following both RFA and ER at the 3 different spinal levels. Similarly, no studies of which we know have described RFA or ER in the thoracic spine, likely due to the high variability of the medial branch in this region.

In this retrospective study, we compared the effectiveness of percutaneous RFA to ER for 234 patients who underwent unsatisfactory RFA followed by ER at the 3 spinal regions. At the aggregate level, both procedures were associated with a significant reduction in pain level, opioid intake, and longer duration of relief compared to the baseline. ER was associated with more significant reductions in all endpoints than was RFA. The mean duration of relief after ER was almost double that of the period after RFA (336 days vs. 179, respectively, $P < 0.00001$). ER resulted in a greater decrease in opioid consumption than RFA, with a mean difference of 7.31 mg for ER compared to 4.45 mg for RFA ($P < 0.05$). These findings collectively suggest that while both ER and RFA are effective in alleviating pain and reducing opioid consumption, ER may provide a more significant reduction in the need for opioids than may RFA.

Additionally, our study included an analysis of outcomes from procedures performed in the cervical, thoracic, and lumbar regions of the spine. These spine regions are anatomically and functionally distinct, and each segment requires variation and nuance in proce-

Table 4. *Differential outcomes of the mean differences pre- and post-op for RFA and ER procedures by the spinal location. P-values generated by t-test (n > 30) or Wilcoxon ranked sum.*

Spinal Level	Mean Difference in VAS Change (ER-RFA)	*P*-value	Mean Difference in Duration of Relief (ER-RFA)	*P*-value	Mean Difference in MME Change (ER-RFA)	*P*-value
Cervical (C3-C7)	-0.023 +/- 0.31	0.5291	115.33 +/- 63.62	0.0361*	3.18 +/- 2.50	0.1024
Thoracic (T1-T12)	0.75 +/ 0.48	0.0592	121.89 +/- 71.56	0.0470*	0.83 +/ 4.46	0.8525
Lumbar (L3-S1)	0.63 +/- 0.17	< 0.0001*	179.43 +/- 23.88	< 0.0001*	3.00 +/- 1.91	0.0588

Values are mean +/- SE. *Indicates statistical significance.

dural technique. Differences among these regions may have confounded the analysis of our combined procedural outcomes.

When ER was compared to RFA for each spinal region independently, the associated duration of relief remained significant for ER, a result similar to findings from other studies (23,29-31). However, when we assessed the opioid consumption for each procedure per spinal region, the mean difference in opioid consumption became insignificant, and the mean difference in pain level remained significant only for L3-S1. Li et al compared ER (in 14 patients) with conservative treatment (in 11 patients) with triple anesthetic in the cervical region. The results showed that patients in the ER group had lower scores on the VAS and Oswestry Disability Index (ODI) and higher McNab scores at one-year follow-up, indicating more consistent ablation of the medial and lateral branches (30). However, in our study, when the 2 groups were compared, the duration of relief was the only outcome that remained significantly different for patients whose cervical pain was treated with ER.

In contrast to the cervical region, the lumbar area showed significantly better VAS scores and longer duration of pain relief with ER. Those results were consistent with those found by Xue et al (23), who reported longer relief duration at 6 months for chronic lumbar pain with ER (n = 30) than with RFA (n = 30). Similarly, Song et al found that ER (n = 20) produced significantly lower VAS and ODI scores at 2 years than did RFA (n = 20) (36). Du et al (31) also reported significantly less pain and a longer duration of relief after ER (n = 19) than after RFA (n = 36) at 20 months on the pain survival curve in their open-label study. Interestingly, in 40 patients with lower back pain, Meloncelli et al (22) found that the receipt of a previous RFA procedure did not have an impact the patients' Numeric Rating Scale and ODI scores after subsequent ER at 24 months. While our findings indicate that ER is more effective for lumbar facet joint syndrome than RFA is and thus may be considered as initial treatment, for patients who undergo RFA first, the results found by Meloncelli et al suggest that ER will remain an effective subsequent procedure.

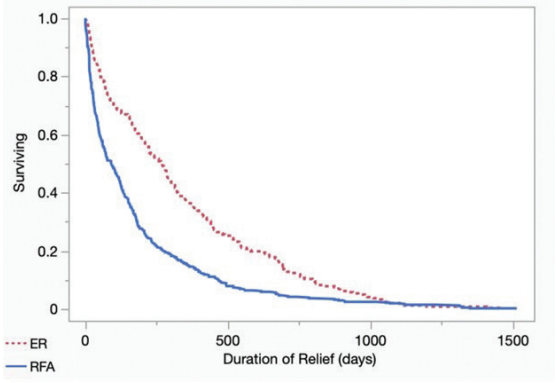

Fig. 4. *Kaplan-Meier curves for the duration of relief for RFA and ER. The median pain-free periods are 336 days for ER and 178 days for RFA. The difference between the 2 survival curves is statistically significant (P < 0.0001).*

We cannot compare our findings in the thoracic area, which reportedly experienced significantly greater duration of relief when treated with ER than with RFA, since we could not find any studies that focused on the use of ER in this region.

Limitations

Firstly, the study design was retrospective and nonrandomized, which introduced bias. Additionally, the study population consisted of patients with chronic zygapophysial joint pain, which may limit the generalizability of our findings to other types of back pain. Moreover, we did not use functional scales. Instead, we used subjective VASs, which may have a bias, but their reliability has already been proven in many studies (37-39). Therefore, we consider the present data to be mainly reliable. ER, nevertheless, is not yet widely available to the general public.

Our findings suggest that ER may provide a more

sustained and long-term solution for patients with facet joint syndrome. However, it is essential to consider the longer operative duration and higher medical expenses associated with ER, since these factors may affect the feasibility and accessibility of the procedure (15). Compared to RFA, ER demonstrates a longer operative time and higher initial cost. Specifically, the average operative time for RFA is 35.3 ± 7.6 minutes, whereas ER averages 61.9 ± 12.9 minutes. The direct medical costs also differ significantly, with RFA costing $979.1 ± 99.0 USD and ER costing $3,964.0 ± 154.9 USD. Despite these figures, when annual medical expenses are adjusted for pain-free duration, ER shows a more favorable cost-effectiveness profile. The annual costs amount to $2,378.4 USD for ER and $1,174.9 USD for RFA, indicating that despite the higher upfront costs, ER may offer extended relief that balances overall expenses over time (31). As for anesthesia requirements, light sedation with fentanyl and midazolam is commonly used for ER and RFA in the lumbar and thoracic regions, depending on patient tolerance. For cervical procedures, general anesthesia is typically required to minimize patient movement, thereby reducing the risk of injury to surrounding structures. At our institution, the preoperative clearance protocols also differ between the 2 procedures. While RFA requires medical clearance for patients classified as ASA 3 and above, ER necessitates clearance for patients who are ASA 2 and higher, reflecting the more complex nature of the ER procedure. We recommend future prospective, randomized controlled trials to validate these findings and further explore the long-term cost-benefit profiles of ER and RFA.

Conclusion

In conclusion, our study compares the differential outcomes of ER and RFA in terms of pain relief, duration of relief, and opioid consumption in patients with facet joint syndrome. The findings suggest that ER may offer a more extended period of pain relief in all spinal regions, with superior pain relief in the lumbar region, though without a significant difference in opioid consumption among patients. However, clinicians choosing between ER and RFA should consider individual patient factors, operative duration, and associated costs. Future prospective, randomized controlled trials are needed to further investigate and validate these findings and assess the long-term cost-benefits analysis related to ER and RFA.

Author Contributions

RSTG and BY had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. BY and RSTG designed the study protocol. RSTG managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. RSTG, MNN, CS, DM, HS, ED, GECA, BR, GW, MH, and BY provided revision for intellectual content and final approval of the manuscript.

Acknowledgments

Firstly, we thank our patients for seeking our service. We also thank the administrative staff of the Spine Institute of North America and the MedStar-Georgetown IRB Review Board.

References

1. Chan AY, Mullin JP, Wathen C, Benzel EC. Degenerative spinal disease (cervical). In: *Principles of Neurological Surgery*. 4th ed. Elseviers, 2018:549-553.
2. Inoue N, Orías AAE, Segami K. Biomechanics of the lumbar facet joint. *Spine Surg Relat Res* 2020; 4:1-7.
3. Chiravuri S, Brummett CM, Kohan L. Facet joint pain. The American Society of Regional Anesthesia and Pain Medicine (ASRA). Published 08/06/2019. www.asra.com/news-publications/asra-updates/blog-landing/legacy-b-blog-posts/2019/08/06/facet-joint-pain
4. Janapala RN, Manchikanti L, Sanapati MR, et al. Efficacy of radiofrequency neurotomy in chronic low back pain: A systematic review and meta-analysis. *J Pain Res* 2021; 14:2859-2891.
5. Manchukonda R, Manchikanti KN, Cash KA, Pampati V, Manchikanti L. Facet joint pain in chronic spinal pain: An evaluation of prevalence and false-positive rate of diagnostic blocks. *J Spinal Disord Tech* 2007; 20:539-545.
6. Casiano VE, Sarwan G, Dydyk AM, Varacallo MA. Back pain. In; *StatPearls*. StatPearls Publishing, 2023. Updated 12/11/2023. www.ncbi.nlm.nih.gov/books/NBK538173/
7. Curtis L, Shah N, Padalia D. Facet joint disease. In: *StatPearls*. StatPearls Publishing, 2024. Updated 03/27/2025. Accessed 08/01/2024. www.ncbi.nlm.nih.gov/books/NBK541049/#:~:text=Reproduction%20of%20the%20patient
8. Perolat R, Kastler A, Nicot B, et al. Facet joint syndrome: From diagnosis to interventional management. *Insights Imaging* 2018; 9:773-789.
9. El Sayed M, Callahan AL. Mechanical back strain. In: *StatPearls*. StatPearls Publishing, 2023. Updated 08/08/2023. www.ncbi.nlm.nih.gov/books/NBK542314
10. Dieleman JL, Cao J, Chapin A. US health care spending by payer and health condition, 1996-2016. *JAMA* 2020; 323:863-884.

11. Kyrosis I, Paraskevopoulos E, Koumantakis GA, Christakou A. The relationship between heart rate variability, pain intensity, pain catastrophizing, disability, quality of life and range of cervical motion in patients with chronic non-specific neck pain: A cross-sectional study. *Healthcare (Basel)* 2024; 12:1055.
12. Manchikanti L, Kosanovic R, Cash KA, et al. Assessment of prevalence of cervical facet joint pain with diagnostic cervical medial branch blocks: Analysis based on chronic pain model. *Pain Physician* 2020; 23:531-540.
13. Manchikanti L, Kosanovic R, Pampati V, et al. Low back pain and diagnostic lumbar facet joint nerve blocks: Assessment of prevalence, false-positive rates, and a philosophical paradigm shift from an acute to a chronic pain model. *Pain Physician* 2020; 23:519-530.
14. CGS Administrators, LLC. Local Coverage Determination (LCD). Facet Joint Interventions for Pain Management (L38773). Revision Effective Date 03/17/2022.
15. Streetman, Fricker, Garner, et al. Endoscopic rhizotomy for facetogenic back pain: A review of the history, financial considerations, patient selection criteria, and clinical outcomes. *World Neurosurg* 2023; 169:36-41.
16. Manchikanti L, Kaye AD, Soin A, et al. Comprehensive evidence-based guidelines for facet joint interventions in the management of chronic spinal pain: American Society of Interventional Pain Physicians (ASIPP) guidelines. *Pain Physician* 2020; 23:S1-S127.
17. Tatli, Tapan, Morrison, Silverman. Radiofrequency ablation: Technique and clinical applications. *Diagn Interv Radiol* 2012; 18:508-516.
18. Khan M, Meleka S. CT guided cervical medial branch block and radiofrequency ablation. *J Clin Neurosci* 2020; 78:393-396.
19. Manchikanti, Kaye, Boswell, et al. A systematic review and best evidence synthesis of effectiveness of therapeutic facet joint interventions in managing chronic spinal pain. *Pain Physician* 2015; 18:E535-E582.
20. Manchikanti L, Kosanovic R, Pampati V, Sanapati MR, Hirsch JA. Outcomes of cervical therapeutic medial branch blocks and radiofrequency neurotomy: Clinical outcomes and cost-utility are equivalent. *Pain Physician* 2022; 25:35-47.
21. Rohof O, Chen CK. The response to radiofrequency neurotomy of medial branches including a bipolar system for thoracic facet joints. *Scand J Pain* 2018; 18:747-753.
22. Meloncelli S, Germani G, Urti I, et al. Endoscopic radiofrequency facet joint treatment in patients with low back pain: Technique and long-term results. A prospective cohort study. *Ther Adv Musculoskelet Dis* 2020; 12:1759720X20958979.
23. Xue Y, Ding T, Wang D, et al. Endoscopic rhizotomy for chronic lumbar zygapophysial joint pain. *J Orthop Surg Res* 2020; 15:4.
24. Barnsley L. Percutaneous radiofrequency neurotomy for chronic neck pain: Outcomes in a series of consecutive patients. *Pain Med* 2005; 6:282-286.
25. Manchikanti L, Kosanovic R, Pampati V, et al. Equivalent outcomes of lumbar therapeutic facet joint nerve blocks and radiofrequency neurotomy: Comparative evaluation of clinical outcomes and cost utility. *Pain Physician* 2022; 25:179-192.
26. Lee CH, Chung CK, Kim CH. The efficacy of conventional radiofrequency denervation in patients with chronic low back pain originating from the facet joints: A meta-analysis of randomized controlled trials. *Spine J* 2017; 17:1770-1780.
27. Le V, Do PT, Nguyen AM, Dao LTN. Thermal radiofrequency ablation combined with corticosteroid injection in management of lumbar facet joint pain: A single-center study in Vietnam - ScienceDirect. *World Neurosurg* 2022; 166:237-243.e1.
28. Kornick C, Kramarich SS, Lamer TJ, Todd Sitzman B. Complications of lumbar facet radiofrequency denervation. *Spine (Phila Pa 1976)* 2004; 29:1352-1354.
29. McDonald GJ, Lord SM, Bogduk N. Long-term follow-up of patients treated with cervical radiofrequency neurotomy for chronic neck pain. *Neurosurgery* 1999; 45:61-68.
30. Manchikanti L, Knezevic NN, Knezevic E, et al. A systematic review and meta-analysis of the effectiveness of radiofrequency neurotomy in managing chronic neck pain. *Pain Ther* 2023; 12:19-66.
31. Du T, Lu G, Li J, et al. Prospective study pain-free survival after endoscopic rhizotomy versus radiofrequency for lumbar facet joint pain: A real-world comparison study. *Pain Physician* 2022; 25:E87-E94.
32. Li ZZ, Hou SX, Shang WL, Song KR, Wu WW. Evaluation of endoscopic dorsal ramus rhizotomy in managing facetogenic chronic low back pain. *Clin Neurol Neurosurg* 2014; 126:11-17.
33. Jeong, Kim, Choi, Hur, Ryu. The effectiveness of endoscopic radiofrequency denervation of medial branch for treatment of chronic low back pain. *J Korean Neurosurg Soc* 2014; 56:338-343.
34. Anjana Reddy VS, Sharma C, Chang KY, Mehta V. 'Simplicity' radiofrequency neurotomy of sacroiliac joint: A real life 1-year follow-up UK data. *Br J Pain* 2016; 10:90-99.
35. Lord SM, Barnsley L, Wallis BJ, McDonald GJ, Bogduk N. Percutaneous radio-frequency neurotomy for chronic cervical zygapophyseal-joint pain. *N Engl J Med* 1996; 335:1721-1726.
36. Song K, Li Z, Shuang F, et al. Comparison of the effectiveness of radiofrequency neurotomy and endoscopic neurotomy of lumbar medial branch for facetogenic chronic low back pain: A randomized controlled trial. *World Neurosurg* 2019; 126:e109-e115.
37. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for pain (VAS pain), Numeric Rating Scale for pain (NRS pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain scale (SF-36 BPS), and measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken)* 2011; 63:S240-S52.
38. Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. *Acad Emerg Med* 2001; 8:1153-1157.
39. Chapman JR, Norvell DC, Hermsmeyer JT, Bransford RJ, DeVine J, McGirt MJ, et al. Evaluating common outcomes for measuring treatment success for chronic low back pain. *Spine* 2011; 36:S54-S68.
40. Boonstra AM, Preuper HRS, Reneman MF, Posthumus JB, Stewart RE. Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. *Int J Rehabil Res* 2008; 31:165-169.