

# THE EFFICACY AND SAFETY OF RADIOFREQUENCY NEUROTOMY IN THE TREATMENT OF CHRONIC CERVICAL FACET (ZYGAPOPHYSEAL) JOINT PAIN: A RETROSPECTIVE STUDY

© Burcu Candan<sup>1</sup>, © Semih Güngör<sup>1,2</sup>

<sup>1</sup>Hospital for Special Surgery, Critical Care and Pain Management, Clinic of Anesthesiology, Division of Musculoskeletal and Interventional Pain Management, New York, United States of America

<sup>2</sup>Weill Cornell Medicine, Department of Anesthesiology, New York, United States of America

## ABSTRACT

**Objective:** To investigate the efficacy and safety of traditional radiofrequency ablation (TRFA) for the treatment of cervical facet-mediated pain. We evaluated 169 TRFA procedures performed on 64 patients who had clinical diagnoses of chronic cervical facet-mediated pain. TRFA was performed in patients who were refractory to conservative therapy and responded favorably to two sets of diagnostic medial branch blocks.

**Materials and Methods:** For patients who underwent TRFA, pain scores were recorded on a numeric rating scale (NRS) at different pre-treatment and post-treatment follow-up (FU) time points [1<sup>st</sup> (4-8 weeks), 2<sup>nd</sup> (>2-6 months) and 3<sup>rd</sup> (>6 months)]. The primary outcomes were NRS improvement and average improvement from baseline NRS (at least 50% or more) at each FU time point. The secondary outcome measure was the time to repeat treatment with subsequent cervical TRFA.

**Results:** The primary outcome measure was achieved in 1<sup>st</sup> FU time-point with 56.75% pain reduction. In the 2<sup>nd</sup> and 3<sup>rd</sup> FU, we found a 47.66% and 21.47% reduction in NRS, respectively. Our subgroup analysis of the age of the patients demonstrated that the younger ( $\leq 50$ ) age groups showed superior pain relief with cervical TRFA in both the 1<sup>st</sup> and 2<sup>nd</sup> FU time points, with 58.36% and 53.46% reduction in NRS, respectively.

**Conclusion:** TRFA is an effective and safe procedure for the treatment of cervical facet-related pain in the early (<2 months) and intermediate terms (2-6 months). There was partial recurrence of pain in the long term (>6 months) in all age groups.

**Keywords:** Cervical pain, facet joint mediated cervical pain, facet radiofrequency ablation, neurotomy, zygapophyseal

## INTRODUCTION

Chronic neck pain is a common and challenging health problem, leading to significant rates of disability and high economic costs<sup>(1)</sup>. The point prevalence rates of chronic neck pain vary between 6% and 22%<sup>(1-3)</sup>. The lifetime prevalence of chronic neck pain among the adult population was reported to vary from 14.2% to 71%, with an average of 48.5%<sup>(3)</sup>.

Cervical spine-related pain may originate from multiple anatomical structures such as cervical zygapophyseal (facet) joints, intervertebral discs, nerve roots, dura, ligaments, fascia, and muscles. Upper neck pain and occipital headaches may originate from the upper cervical zygapophyseal joints, which are known as cervicogenic headaches<sup>(4)</sup>. Among the studies with diagnostic and controlled blocks, it has been shown that the cervical facet joints account for 50% to 60% of chronic neck pain cases<sup>(5-7)</sup>.

Two important factors may serve as the reason for the high incidence of cervical facet joint pain in chronic neck pain: (a) the density of mechanoreceptors in cervical facet joints is higher compared to density in lumbar facet joints<sup>(8)</sup>, and (b) cervical facet joints are susceptible to injury during trauma<sup>(9)</sup>. The success of minimally invasive pain interventions for cervical facet joint pain depends highly on the proper selection of patients based on clinical features. The level of diagnostic blocks must be planned using facet joint referral maps<sup>(10,11)</sup>. The research indicates that physical and neurologic examinations may not be effective in identifying the origins of symptomatic facet joint-related pain. Moreover, observation of facet joint arthrosis on plain radiographs, computed tomography, or magnetic resonance imaging may not be predictive of facet joint-related pain<sup>(11)</sup>. Controlled diagnostic medial branch blocks (MBB) are the main validated modality for the diagnosis of facet joint-related pain<sup>(12,13)</sup>.

**Address for Correspondence:** Burcu Candan, Hospital for Special Surgery, Critical Care and Pain Management, Clinic of Anesthesiology, Division of Musculoskeletal and Interventional Pain Management, New York, United States of America

**Phone:** +90 532 203 92 83 **E-mail:** burcu.candan@gmail.com **Received:** 01.04.2024 **Accepted:** 20.05.2024

**ORCID ID:** orcid.org/0000-0003-2241-1225



Radiofrequency ablation (neurotomy) of the medial branch nerves with sensory innervation to the specific facet joints is among the best-validated treatments for facet joint-related pain<sup>(11,14)</sup>. When diagnostic blocks of the nerves with sensory innervation to the specific facet joints relieve the pain temporarily, radiofrequency ablation of the same nerves can be applied for prolonged benefits<sup>(12,15)</sup>. The evidence is level II in the management of neck pain with cervical radiofrequency neurotomy and level III to IV for cervicogenic headache<sup>(15,16)</sup>. This retrospective study aims to investigate the efficacy of traditional radiofrequency ablation (TRFA) for patients with the diagnosis of chronic neck pain originating from the cervical facet joints.

## MATERIALS AND METHODS

This study was conducted at a single urban, academic pain medicine center specializing in the treatment of musculoskeletal disorders. The study was approved by the Institutional Review Board (IRB) (2023-0711), and the IRB waived the requirement for written consent. Data were collected by retrospective chart review.

We analyzed 169 consecutive cervical zygapophyseal (facet) joint radiofrequency ablation (neurotomy) procedures performed on 64 patients by a single practitioner in our institution from July 2011 to March 2023. Sixty-four patients who underwent the 169 procedures at different levels on separate occasions were treated as separate individuals in the results.

We performed TRFA procedures in eligible patients with a diagnosis of cervical facet joint pain who are refractory to conservative therapy. A written informed consent was obtained from each patient for the procedure. We evaluated the pain levels on the numeric rating scale (NRS), the duration for the requirement of repeat radiofrequency denervation at the same levels, and adverse effects from the procedure.

Pretreatment and posttreatment NRS were recorded prior to the procedure at 4 to 8 weeks (early), 2 to 6 months (intermediate-term), and 6 to 12 months (long-term) time points. Each patient's follow-up (FU) period was at least 12 months.

### Patient Selection

Patients with neck pain refractory to conservative therapy for at least six months and fulfilling the inclusion criteria outlined below were recommended diagnostic MBB for the levels between C2 to T1 zygapophyseal joints, depending on the levels selected by the clinical and radiological evaluation of the patients. All patients who consented to this therapy underwent dual diagnostic MBB of the related facet joints. In eligible patients who responded to dual diagnostic medial blocks favorably ( $\geq 80\%$  temporary pain relief consistent with the duration of the local anesthetic used) and consented to the procedure, the TRFA procedure was performed. All patients who underwent TRFA with documented FU in all predetermined time points were included in the study.

### Inclusion Criteria

- Age between 18 and 85 years.
- $\geq 6$  months history of non-specific cervical pain.
- Refractory to conservative treatment, including activity modification, home exercises, physical therapy, and medication management.
- Pretreatment pain levels of  $\geq 5$  in NRS.
- The following criteria make a preliminary clinical diagnosis of cervical facet-related pain:
  - a. Non-specific neck pain in the cervical spine.
  - b. Absence of cervical radiculopathy.
  - c. As indicated, X-rays, computed tomography, or magnetic resonance imaging studies were performed to exclude the possibility of pathology that was amenable to primary therapy.
  - d. Some of the examination findings are suggestive, but not an absolute requirement, for diagnosis of cervical facet joint mediated pain, such as reproduction of pain with palpation of the corresponding facet joints and extension maneuver of the cervical spine.
- The patients fulfilling the inclusion criteria outlined above were recommended diagnostic MBB.
- The area of pain was marked on the skin prior to MBB, and the actual spinal levels of MBB were determined under fluoroscopic counting of the corresponding levels. In each patient, diagnostic local anesthetic blocks of either 3 or 4 medial branches, corresponding to 2 or 3 facet joint levels, respectively, were performed.
- $\geq 80\%$  temporary pain relief after dual diagnostic MBB with 0.5 mL of lidocaine 2% or 0.5 mL of bupivacaine 0.5% in two different sessions.

### Exclusion Criteria

- Disc herniation, stenosis, myelopathy, cervical fracture, and suspected radiculitis.
- Previous history of spinal surgery at the level of intervention.
- Systemic or local infection.
- Coagulation disorder.
- Allergy to iodinated contrast.
- Rheumatic disorders.
- Malignancy.
- Pregnancy.
- An uncontrolled medical or psychiatric condition.

### Statistical Analysis

The primary outcome measure was to report descriptive NRS pain score and average % improvement from baseline at each time point. A significant pain relief was determined by a decrease of at least 50% or more of mean NRS. Pain relief was also categorized as early relief at 4 to 8 weeks, intermediate-term relief at 2 to 6 months, and long-term relief at 6 to 12 months post-procedure. The secondary outcome measure, which is the duration of treatment, was quantified in terms of the time to repeat treatment with a subsequent TRFA. Adverse events were also recorded.

Sample size was determined empirically. To mitigate selection bias, all eligible patients from the hospital records were included in the cohort. Patient characteristics were summarized as count, mean, or ratio as appropriate to the context. Tables were utilized to report the changes in NRS scores and corresponding pain relief percentages, along with their mean values, standard deviations, 95% confidence interval bounds, and associated p-values observed across all patients during FU assessments. Distribution of pain scores and count levels was assessed using histograms. Analyses were conducted using SPSS 28.

### MBB and TRFA Procedure

All patients underwent the procedure awake under local anesthesia. No sedatives were given before the procedures. Patients were positioned prone with a C-arm fluoroscopy with an anteroposterior view of the appropriate level of the spine. After local anesthetic was given for entry points, 22-gauge spinal needles were placed in the appropriate location described as cervical MBB in Spinal Intervention Society Guidelines<sup>(17)</sup>. All patients underwent diagnostic MBB of the related facet joints with 0.5 mL of lidocaine 2% or 0.5 mL of bupivacaine 0.5% in two different sessions. In eligible patients who responded to dual diagnostic medial blocks favorably ( $\geq 80\%$  temporary pain relief consistent with the duration of the local anesthetic used) and consented to the procedure, the TRFA procedure was offered. In the TRFA procedure, 22-gauge, 5 or 10 cm, 5 mm active tipped TRFA electrodes were placed in the appropriate location similar to those described as cervical MBB in Spinal Intervention Society Guidelines<sup>(17)</sup>. After appropriate testing for sensory and motor components, 1 mL of Lidocaine 1% was injected through each needle prior to the TRFA procedure. Radiofrequency denervation was carried out at 70 °C for 90 seconds for each level (NeuroTherm NT2000iX RF Generator, Abbott, USA). No further medication was given at the procedure site post-procedure. All the procedures were done by the same fellowship-trained and board-certified interventional pain specialist with over 20 years of experience.

## RESULTS

We evaluated the data from 169 TRFA procedures in 64 patients obtained during their pre-procedural and post-procedural FU visits. Data collected from the 1<sup>st</sup> (4-8 weeks), 2<sup>nd</sup> (>2-6 months) and 3<sup>rd</sup> (>6-12 months) FUs were used to determine the short- and long-term outcomes of cervical TRFA. The mean NRS scores were recorded and analyzed to quantify the average improvements in NRS. We also performed a subgroup analysis of the data based on age ( $\leq 50$  versus  $>50$ ). There were no complications reported in 169 procedures.

As shown in Figure 1 and summarized in Table 1, the majority of patients were female: 45 out of 64 patients were female with a mean age of 47.95; the remaining 19 patients were male with a mean age of 50.20. The overall age range was 24-70 years, with a mean of 48.66. As shown in Table 1, based on their symptoms, patients needed repeated TRFA procedures due to the presence of recurrent pain.

As shown in Table 2, the average NRS at baseline was 7.41 for all age groups. Improvement of pain was 56.75% (mean NRS: 3.18) in the 1<sup>st</sup> FU (4-8 weeks). In the 2<sup>nd</sup> FU (>2-6 months), there was a 47.66% improvement in the pain scores (mean NRS: 3.85). In the 3<sup>rd</sup> FU (>6-12 months), the recorded improvement of the pain scores was 21.47% (mean NRS: 5.57).

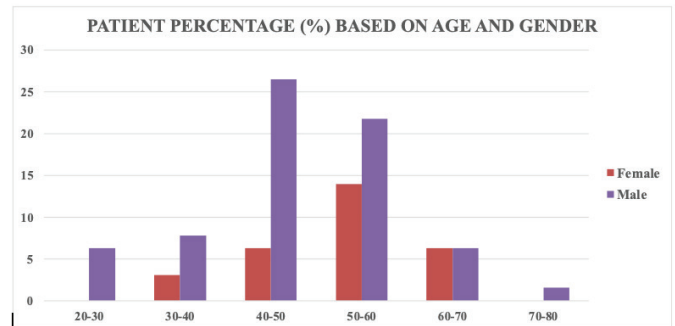


Figure 1. Patient percentage based on gender and age

Table 1. Descriptive statistics of the baseline demographic and procedural characteristics

	Number of patients	Mean age	Number of procedures	Percentage of procedures
Female	45	47.95	106	62.72
Male	19	50.20	63	32.28
All	64	48.66	169	100

Table 2. Changes in NRS scores and corresponding pain relief percentages, including mean values, SD, and 95% confidence interval bounds, observed across all patients during FU assessments

	NRS				Pain relief			
	Mean	SD	95% confidence interval		Mean	SD	95% confidence interval	
			Lower	Upper			Lower	Upper
Pre-TRFA	7.41	1.11	7.24	7.58				
1 <sup>st</sup> FU	3.18	1.63	2.92	3.44	56.75%	20.55%	53.46%	60.03%
2 <sup>nd</sup> FU (2-6 m.)	3.85	2.10	3.50	4.21	47.66%	29.00%	42.72%	52.59%
3 <sup>rd</sup> FU (7-12 m.)	5.57	2.31	5.12	6.01	21.47%	37.79%	14.22%	28.71%

NRS: Numeric rating scale, SD: Standard deviation, FU: Follow-up, TRFA: Traditional radiofrequency ablation, m.: Month

We also performed a subgroup analysis of the data based on the age and pain scores of patients in different age categories ( $\leq 50$  versus  $> 50$ ). Among the 169 TRFA procedures, there were 21 bilateral procedures (12.42% of the total). As shown in Table 3, distributions of bilateral procedures were similar in both age groups (10 for the  $\leq 50$  years group and 11 for the  $> 50$  years group). The remainder of the procedures were unilateral.

As we report in Tables 4 and 5, for both age groups, the pain relief was similar in the first (4-8 weeks) and 2<sup>nd</sup> FU ( $> 2-6$  months). Recurrence of pain was also similar in the 3<sup>rd</sup> FU ( $> 6-12$  months). The average baseline NRS (pre-TRFA) level was 7.41. Baseline NRS levels were similar for both age groups (7.62 for ages  $\leq 50$  and 7.21 for ages  $> 50$ ).

• Our primary outcome measure was the adequate reduction of pain scores (50% or more). As shown in Table 4, our primary outcome was achieved in the first FU period in both age groups (58.36% and 55.42%, respectively). For  $\leq 50$  years-old patients;

the pain reduction at the second FU (53.46%) also achieved our primary outcome, though this result is statistically weaker as observed by the p-values reported in the table. While the pain relief (43.15%) was also good for  $> 50$  years-old patients' in the second FU, our primary outcome of 50% or more pain relief was not met in this age group.

• Figure 2 and Table 4 show a partial recurrence of pain when compared to baseline NRS in the third FU period ( $> 6-12$  months) in both groups. For the  $\leq 50$  years-old patients' group, the pain level was 5.52 (indicating a 25.36% reduction), and for the  $> 50$  years-old patients' group, the pain level was 5.61 (indicating a 17.79% reduction). Note that the pain relief confidence intervals for the age groups  $\leq 50$  and  $> 50$  do intersect, indicating that the age difference does not make statistically significant difference in pain relief.

As reported in Table 5, there were 58 repeated radiofrequency neurotomy procedures: 25 (43.1%) of these were in the  $\leq 50$  age group, and 33 (56.9%) were in the  $> 50$  age group:

• Most of the repeated TRFA procedures were performed early: 25 of these procedures (10 for the  $\leq 50$  age group and 15 for the  $> 50$  age group) were performed between 6 and 12 months.  
 • Younger patients most frequently needed a repeated TRFA procedure between years 1 and 2 (13 procedures), while the

**Table 3.** Descriptive statistics of the procedural characteristics

	Unilateral	Bilateral	All
$\leq 50$ years	71	10	81
$> 50$ years	77	11	88
All	148	21	169

**Table 4.** Changes in corresponding pain relief percentages, including mean values, standard deviations, 95% confidence interval bounds, and p-values observed across all patients during FU assessments

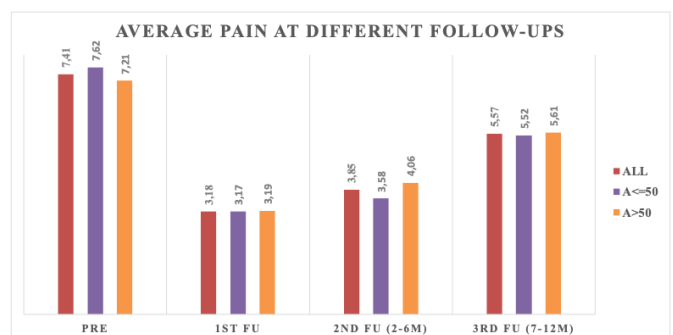
		Mean	SD	95% confidence interval		Significance	
				Lower	Upper	One-sided p	Two-sided p
1 <sup>st</sup> FU	A $\leq 50$	58.36%	20.90%	53.34%	63.38%	<0.001	0.001
	A $> 50$	55.42%	20.28%	51.02%	59.82%	0.008	0.016
	All	56.75%	20.55%	53.46%	60.03%	<0.001	<0.001
2 <sup>nd</sup> FU (2-6 m.)	A $\leq 50$	53.46%	26.43%	46.57%	60.35%	0.159	0.319
	A $> 50$	43.15%	30.26%	36.24%	50.06%	0.026	0.052
	All	47.66%	29.00%	42.72%	52.59%	0.175	0.349
3 <sup>rd</sup> FU (7-12 m.)	A $\leq 50$	25.36%	33.60%	16.00%	34.71%	<0.001	<0.001
	A $> 50$	17.79%	41.34%	6.61%	28.97%	<0.001	<0.001
	All	21.47%	37.79%	14.22%	28.71%	<0.001	<0.001

FU: Follow-up, SD: Standard deviation, m.: Month

**Table 5.** Requirement of repeated TRFA based on different age groups

	All	$\leq 50$ year	$> 50$ year
<6 month	0	0	0
>6 month to 1 year	25	10	15
>1 year to 2 year	22	13	9
>2 year	11	2	9
Total	58	25	33

TRFA: Traditional radiofrequency ablation

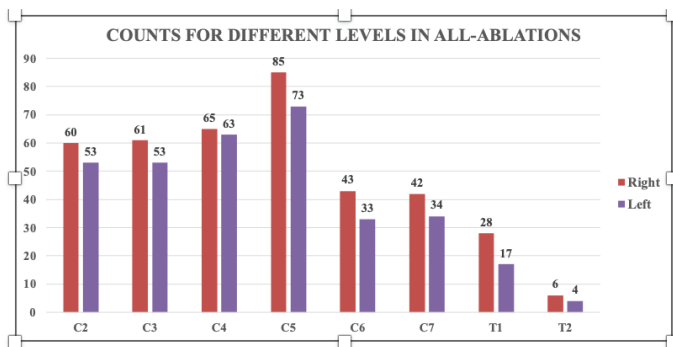


**Figure 2.** Average pain in different FUs based on age of patients age ( $\leq 50$  vs.  $> 50$ )  
 FU: Follow-up

older group needed repetitions earlier (6 months to 1 year, with 15 procedures).

- The longest duration of pain relief requiring repeated TRFA was 230 weeks for the age group  $\leq 50$  and 228 weeks for the age group  $>50$ .
- The shortest duration of pain relief requiring repeated TRFA was 30 weeks for the age group  $\leq 50$ , and the longest duration was 25 weeks for the age group  $>50$ .
- No patients required a repeated procedure during the first six months.

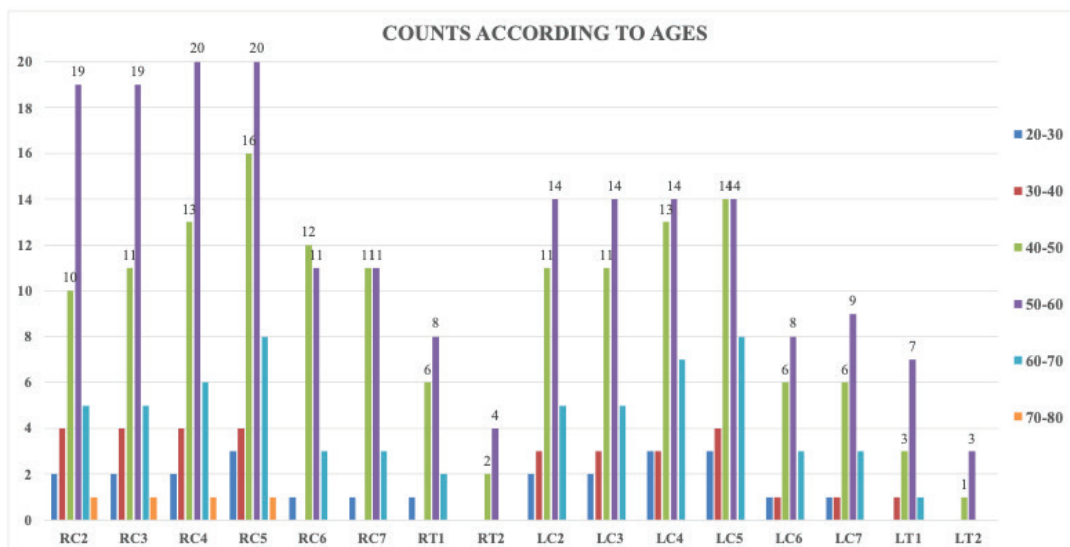
Figure 3 presents the distribution of the levels for the TRFA applications. As we see in this chart, most TRFA applications were for the higher cervical levels (C2, C3, C4, and C5) for both the left and right sides. In particular, the C5 level received the largest number of ablations. Figure 4 shows the distribution of the levels for different age groups; for all age groups, C2, C3, C4, and C5 levels received the largest numbers of ablations, with the 50-60 age group receiving the largest share of all ablations performed, followed closely by the 40-50 age group.



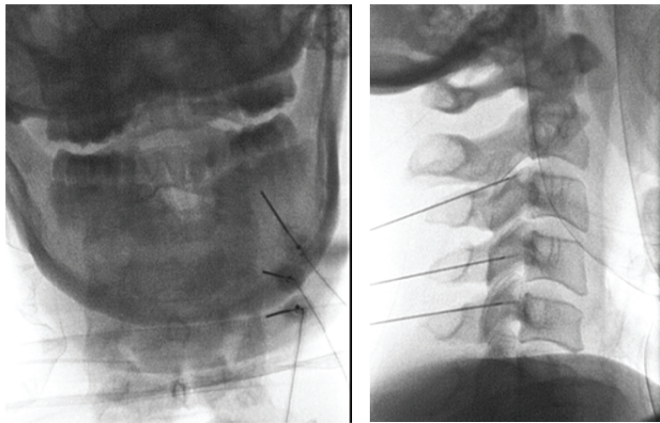
**Figure 3.** Distribution of the ablations performed at different cervical levels

## DISCUSSION

There is strong evidence that TRFA/neurotomy of medial branches provides symptomatic relief for chronic pain originating from facet joints in the cervical and lumbar spine<sup>(18,19)</sup> (Figure 5 illustrates both the anteroposterior and lateral fluoroscopic images of cervical TRFA). However, certain limitations about the efficacy of this therapy for spine-related pain have also been reported<sup>(20-23)</sup>, and long-term relief with this therapy may require repeated neurotomy<sup>(24-27)</sup>. The majority of chronic neck pain patients can experience 80%-100% pain relief for up to a year after the application of TRFA<sup>(24,28)</sup>. A major source of failure for the radiofrequency ablation (RFA) technique in cervical applications is the false-positive responses to diagnostic blocks<sup>(29,30)</sup>. False-positive rates in the case of single blocks can be up to 63%<sup>(31)</sup>. Several other factors might contribute to failures, including inadequate patient selection, inaccurate surgical anatomy, and technical errors<sup>(32)</sup>. In our retrospective study, we report the outcomes of cervical TRFA procedures that were applied to the patients who were refractory to conservative therapy and responded favorably to two sets of diagnostic MBB. Our results showed that cervical TRFA is effective in the early period, with more than a 50% reduction in NRS. Sixty-four patients included in our study have received significant short-term pain relief (56.75% decrease in NRS, pre-treatment NRS=7.41 vs. 1<sup>st</sup> FU NRS=3.14). During longer-term FUs (6-12 months), the mean NRS value was 5.57 (21.47% decrease in NRS with respect to the baseline). Younger patients ( $\leq 50$  years of age) have received the most significant pain relief in all FU time points. However, it's noteworthy that the confidence intervals for pain relief in the age groups  $\leq 50$  and  $>50$  overlap (Table 4), suggesting that there is no statistically significant difference in pain relief based on age.



**Figure 4.** Distribution of the ablations performed at different cervical levels for different age groups



**Figure 5.** The anteroposterior (left) and lateral (right) fluoroscopic views of cervical TRFA are shown  
TRFA: Traditional radiofrequency ablation

In a study, Burnham et al.<sup>(33)</sup> indicated that in patients who had temporary improvement with dual concordant MBB of corresponding facet joints, subsequent application of cervical TRFA was an effective treatment modality<sup>(33)</sup>. This study included 50 patients, and the results demonstrated an overall 50% pain reduction rate of 54%. While the results of this study were similar to our results, they used a different mixture of ablation techniques (80% cooled RFA and 20% TRFA).

Barnsley<sup>(34)</sup> presented the results of their study that showed that radiofrequency neurotomy was an effective treatment for chronic cervical zygapophysial joint pain. This study evaluated the outcomes of percutaneous radiofrequency neurotomy of 47 procedures performed on 35 patients with chronic neck pain<sup>(34)</sup>. In this study, 80% of the procedures achieved significant pain relief lasting a mean duration of 36 weeks. In another study, Lord et al.<sup>(34)</sup> demonstrated that radiofrequency neurotomy provided long-lasting relief (with a median time of 263 days to the return of at least 50% of the preoperative level of pain) in a moderate proportion of the patients. In our study, we observed repeated TRFA procedures were applied most frequently between 6 and 12 months, which supports both studies<sup>(33,34)</sup>.

MacVicar et al.<sup>(24)</sup> reported the results of a study where 66% of cervical RF patients achieved complete pain relief, restoration of activities of daily living, and return to work<sup>(24)</sup>. The authors also reported that the patients who responded well to TRFA did not need additional therapy for neck pain for a median duration of 17-20 months. In our study, there was a recurrence of pain in all groups after six months (all patients: 21.47%; age≤50: 25.36%, age>50: 17.79%), and TRFA procedures were most frequently repeated between 6-12 months (the highest rate of repeated procedures was between 6-12 months for the younger patients (age≤50), and between 1-2 year for patients older than 50).

In the published consensus practice guidelines on interventions for cervical spine (facet) joint pain<sup>(12)</sup>, cervical facet joints are indicated as the primary source of pain in 25-67% of chronic neck

pain patients. Cooper et al.<sup>(10)</sup> reported cervical zygapophysial joint pain maps based on areas in which patients are relieved of pain by controlled blocks. According to their results, C2-3 (36%) and C5-6 (35%), followed by C6-7 (17%) joints are the most common sources of neck pain. According to published facet joint pain referral maps<sup>(10,11)</sup>, while upper cervical pain with headache is most likely attributable to the C2-3 facet joint, lower cervical pain more likely originates from C5-6.

In our study, upper cervical facet joints (C2-3, C3-4, C4-5) were more symptomatic than the lower cervical facet joints, including the upper thoracic facet joints. Among all repeated injections, the most frequently ablated medial branches were right C5 and left C5, followed by right C4 and left C4. In our study, patients between ages 40 and 60 had the largest number of TRFA applications, and the most frequently ablated levels were the upper cervical levels, C2, C3, C4, and C5 in this age group.

Our study's primary limitation lies in its retrospective design, which prevents effective FU of each patient. Moving forward, conducting prospective studies with control groups is crucial to validate our findings. Prospective studies allow for comprehensive evaluation of all patients across all FU periods, providing invaluable insights. Therefore, we recommend conducting prospective randomized controlled studies with larger sample sizes to maximize the value of the results obtained.

## CONCLUSION

This retrospective clinical study was designed to evaluate the efficacy of TRFA for facet joint-related pain in the cervical spine. Our data indicates that TRFA is a safe and effective treatment for cervical facet joint-related pain lasting for at least six months. Partial recurrence of pain between 6 and 12 months was observed in all age groups, requiring repeated TRFA procedures.

### Ethics

**Ethics Committee Approval:** The study was approved by the Hospital for Special Surgery Institutional Review Board (approval number: #2023-0711, date: 05.08.2023) and patients provided written informed consent for the procedure from the participants involved.

**Informed Consent:** Retrospective study.

### Authorship Contributions

Surgical and Medical Practices: S.G., Concept: B.C., S.G., Design: B.C., S.G., Data Collection or Processing: B.C., S.G., Analysis or Interpretation: B.C., S.G., Literature Search: B.C., S.G., Writing: B.C., S.G.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

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