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The effectiveness and predictive factors of Sacroiliac Joint Radiofrequency Neurotomy success – A retrospective cohort study

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ABSTRACT

Background: The Sacroiliac Joint (SIJ) accounts for 10–27% of lower back pain. Radiofrequency neurotomy (RFN) is commonly utilized for refractory pain. Outcomes are variable and may be related to patient selection and procedural technique differences.
Objective: To assess the effectiveness and outcome success predictors of SIJ RFN at three months.
Design/Methods: Data of patients undergoing SIJ RFN were extracted from the electronic medical record of one physiatrist's interventional pain practice between 2016 and 2021. The extracted data included the following outcome variables: ≥2 decrease in Numerical Rating Scale (NRS) [minimal clinically important difference MCID-2], ≥50% NRS reduction, and ≥17 points decrease in the Pain Disability and Quality of Life Questionnaire – Spine (PDQQ-S) [MCID]. Predictor variables included block type [>79% LBB/LBB, >79% IA/LBB, 50–79% LBB/LBB, 50–79% IA/LBB, >79% LBB, and 50–79% LBB] and cannula type/configuration [16 g/longitudinal, Trident bipolar/perpendicular, and 18 g quadripolar/perpendicular]. Data analysis included descriptive statistics and logistic regression with an odds ratio (OR). Covariates included in the logistic regression models were age, gender, and laterality (right, left, and bilateral).
Results: Of the 128 patients analyzed for this study (20.8% males; 60.4 ± 14.4 years of age), 66.9% achieved MCID-2 in NRS, 53.9% experienced ≥50% NRS reduction, and 50% experienced ≥17 points decrease in PDQQ-S. Achieving MCID-2 in NRS for the 18 g quadripolar/perpendicular technique was approximately four times higher than the odds for 16 g/longitudinal technique (OR = 3.91; 95% CI = 1.34–11.43; $p = 0.013$). Block type was not significantly associated with any outcome variable after adjusting for cannula type and other covariates ($p > 0.05$). Younger age was significantly associated with achieving MCID-2 in NRS, ≥50% NRS reduction, and ≥17 points decrease in PDQQ ($p = 0.034$, 0.020, and 0.002, respectively).
Conclusion: SIJ RFN effectively reduces pain and improves function in most patients at three months. Quadripolar/perpendicular technique and younger age predict SIJ RFN treatment success, whereas block type does not.

1. Introduction

The Sacroiliac joint (SIJ) complex is comprised of the ligaments and synovial joint that form the articulation between the sacrum and ilium [1]. It consistently receives dorsal innervation from the S1 and S2 lateral branch nerves and variably from the S3 and S4 lateral branch nerves and the L5 dorsal ramus nerve [2]. Ventrally it is innervated by the lumbopelvic rami [3]. Pain in this region is a common cause of morbidity and functional limitation in patients, accounting for 10–27% of lower back pain [4]. Radiofrequency neurotomy (RFN) is a commonly utilized procedure for refractory pain in this region. Studies have demonstrated that, alongside improved pain and function, this procedure can also subsequently decrease health care cost and utilization [5]. Recent meta-analyses support the effectiveness of various SIJ RFN procedural techniques for up to 12 months post-procedure [1,6–8]. A retrospective cohort study comparing SIJ intra-articular steroid injections and SIJ lateral branch RFN demonstrated that both interventions demonstrated significant pain relief with RFN providing longer duration of relief (82

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vs. 38 days) [3]. In general, reported procedural success has been quite variable [4]. The systemic review by King et al. (2015) found that results varied between 32 and 89% of patients achieving at least 50% pain relief at 6 months and 11–44% of patients achieving 100% pain relief at 6 months [1]. At present most procedures are performed under fluoroscopic guidance. However, Burnham et al. (2022) evaluated an ultrasound-assisted longitudinal axis approach [9]. More recently, Loh et al. (2022) published a study evaluating a novel ultrasound-guided approach to SIJ RFN, demonstrating statistically significant decreases in pain intensity up to 9 months, and comparable efficacy to fluoroscopy-guided RFN at 2 months post-procedure [10].

Various factors likely contribute to the reported variability in procedural success, including the absence of large sample sizes, few high-quality randomized controlled trials, and variability in procedural technique and patient selection (i.e., diagnostic injection threshold) [1]. As a result, further research is critical to substantiate this intervention's significance and clinical utility. Our study aimed to assess SIJ RFN effectiveness and outcome predictors of success, including block type, demographics, and procedural technique/cannula type.

2. Materials and methods

This retrospective cohort study was conducted at one physiatrist's practice. The electronic medical records of consecutive patients who underwent SIJ RFN between 2016 and 2021 were reviewed. Local approval by the Conjoint Health Research Ethics Board at the University of Calgary (Ethics ID#: REB20-0355) was obtained.

Data extraction was performed by authors (R.B. and A.A). The inclusion criteria were: (a) Mechanical low back pain that had been refractory to conventional conservative treatment, (b) clinical features suggestive of sacroiliac joint complex pain (i.e. pain below L5, positive Fortin finger test, positive joint provocative test(s)), (c) Fluoroscopically guided lateral branch block(s) with 50% or more pain relief (d) first time SIJ RFN procedure only (excluding repeat procedures) and (e) PDQQ-S pre and 3 months post intervention. In regards to inclusion criterion (c), in determining response to lateral branch blocks, all patients completed a 0–10 scale Numerical Rating Scale based pain diary with recordings made just prior to and at 30 min intervals for 6-h post-block, which was subsequently sent back to our clinic for review. Maximal pain relief within that time (compared to pre-procedural pain level) was calculated mathematically. They were included in the study if this reached 50% or more at any time within this 6-h pain diary. As a further portion of this pain diary, patients were asked if they experienced any functional improvement or improvement in ability to participate in any specific activities, though this was not included as specific inclusion criteria. The exclusion criteria were: (a) diagnostic block >3 years prior to the RFN procedure (b) if the cannula used was outside the scope of this study (i.e. Nimbus, 20G cannula) (c) if diagnostic/prognostic block were done off-site (d) if there were confounding intervention or injury (i.e. epidural or facet joint steroid injection) in the interim between RF and follow up or (e) if the SIJ procedure was performed coincidingly with a lumbar intervention on the same date. From this, we were specifically interested in the predictive value of block paradigm and procedure type on procedure outcome. Additional potential predictor variables were extracted, including: (a) age (b) gender (c) laterality (d) cannula type/configuration.

3. Block paradigms

The LBBs were performed using a combination of ultrasound and fluoroscopic guidance. Patients were not treated with sedation or anxiolysis during injections. With the ultrasound transducer in the transverse plane, the sacral cornua were identified. The transducer was slid laterally until the S4 transverse sacral tubercle was in the middle of the screen with the S4 dorsal sacral foramen lying medially. The transducer was then slid cephalad until the S3 transverse sacral tubercle and S3 dorsal sacral foramen were identified. With the S3 transverse sacral tubercle in the middle of the screen, the overlying skin was marked with indelible ink. The transducer was then slid more cephalad until the S2 and S1 transverse sacral tubercles and adjacent dorsal sacral foramina were identified, and the skin overlying each transverse sacral tubercle was also marked. A vertical line connecting the three markings was drawn and represented the course of the lateral sacral crest. This line was marked with intersecting horizontal lines at 1-cm intervals (typically 4 or 5 intersecting horizontal lines). Under fluoroscopic guidance, a 25-gauge needle was passed through each of the intersecting lines over the lateral sacral crest line down the barrel to lie perpendicular to the periosteum. A total of 0.5 mL of local anesthetic (2% lidocaine and/or 0.5% bupivacaine) was injected at each intersecting line to ensure the complete nociceptive blockade of the posterior sacral network and S1–S3 lateral branch nerves. Typically, only the lateral sacral crest (S1–3) was anesthetized on the first block.

If <80% pain relief was achieved within the first 6 h after LBB, the L5 dorsal ramus was included along with the S1–S3 lateral branch nerves in the second block, as well as within the eventual radiofrequency neurotomy if the second block resulted in superior pain relief. This protocol is based on cadaveric evidence that, in most cases, SI joint sensory innervation is from S1–S3. However, in 8%, L5 also contributes. The path of this branch would not necessarily be captured with a palisade strip lesion which extends superiorly to the lateral border of the S1 dorsal sacral foramen [2,4,11]. All blocks were placed at the periosteal level only rather than multi-depth based on the findings of recent cadaveric dissections confirming that the lateral branch nerves run exclusively along the periosteum [2]. For the purposes of our investigation, patients were required to have had at least 50% relief on at least one lateral branch block prior to completion of RFN. In addition to lateral branch blocks, a proportion of our patients had an intra articular anesthetic and steroid injection performed which was included as part of their block paradigm. If the intra-articular block was negative, lateral branch block was not performed and patients with only an intra articular injection without at least one lateral branch block were not included in our study.

4. Procedures

All procedures were performed with conventional thermal radiofrequency neurotomy using a lesion time of 2 min following a 30 s ramp up and temperature of 80 °C. Three procedural techniques (Fig. 2) were utilized. Based on cannula type/orientation they were: (a) 16 g/longitudinal: this was an ultrasound-assisted procedure that placed a 16 g monopolar cannula with a 2 cm curved active tip at 3 sites along the longitudinal axis of the lateral sacral crest as previously described [8], (b) 18 g quadripolar/perpendicular: this technique involved placing two sets of four 18G cannulae perpendicularly along the lateral sacral crest with an inter-cannula distance of 0.8 cm under fluoroscopic guidance and, (c) Trident bipolar/perpendicular: this technique involved placing 3–4 sets of Trident multitined cannula bipolar lesions perpendicularly along the lateral sacral crest with an inter-cannula distance of 1.5 cm. The inter-cannula distance of 0.8 cm was used based on the work of Cosman and Gonzalez (2011) who demonstrated, in an ex vivo model, that a confluent strip lesion was achieved with bipolar lesioning using two 18 gauge cannula separated by 0.8 cm [12]. Trident inter-cannula distance of 1.5 cm was chosen based on feedback from the manufacturer (Diros Inc.) from ex vivo testing they had performed identifying a confluent inter-cannula strip lesion was achieved with ≤2 cm of cannula separation (personal communication). The determination on whether 3–4 sets (corresponding to 6–8 R F cannula placements) was based on the length of the patient's sacrum and the corresponding distance between the S1 to S3 lateral sacral tubercles.

5. Theory and calculation

Data analysis included descriptive statistics and logistic regression

Interventional Procedure Follow-up Form

Name:_____ DOB:_____

Date of procedure:_____ Type of Procedure:_____

In order to help maximize the quality of your care, it is important that you fill out this form and return it to us.

Please fill out this form on or about the following date:_____, then deliver, mail or fax it back to our clinic.

Relating to your_____ pain, please record your scores in the 2nd column of this table, averaged for the past week:

	At the time of your procedure		3 months after your procedure	
Pain Intensity: how severe has your pain been? 0 = no pain; 10 = worst possible pain		/10		/10
Pain Frequency: how often has your pain been present? 0 = never present; 10 = always present		/10		/10
Disability: because of your pain, how difficult is it for you to do each of the following activities? 0 = no difficulty; 10 = completely unable to do it Difficulty for:		/10		/10
Difficulty for:		/10		/10
Satisfaction: if you had to live with the pain you have now for the rest of your life, how satisfied would you be? 0 = completely satisfied; 10 = completely unsatisfied		/10		/10
Quality of Life: how much has your pain disrupted the quality of your life? 0 = not at all; 10= completely ruined it		/10		/10
Totals:		/60		/60

Fig. 1. Pain disability and quality of life questionnaire spine (pdqq-s).

analysis with the calculations of an odds ratio (OR) and its 95% confidence interval (CI). Outcome variables included the Numerical Pain Rating Scale (NRS 0–10), of which measured success was determined as achievement of either a ≥2 point decrease in NRS (minimal clinically important difference [MCID-2] or a ≥50% NRS reduction and secondly, the Pain Disability and Quality of Life Questionnaire- Spine (PDQQ-S). The PDQQ-S is a previously validated six question patient-reported outcome measure designed for use in the field of minimally invasive interventional spine care [13] and the MCID value for this questionnaire has been determined as a ≥17 point decrease [14], which is what was chosen as an additional measure of efficacy in our study (Fig. 1). Predictor variables included block type (divided into class based on combinations of lateral branch block (LBB) and intra articular local anesthetic/steroid injections (IA) and maximum % relief experienced within 6 h post block; see Table 1), and cannula type/configuration: 16 g/longitudinal [9], Trident bipolar/perpendicular, and 18 g quadripolar/perpendicular. Covariates included in the logistic regression models were age, gender, and laterality (right, left, and bilateral).

6. Results

Of the 198 consecutive patients identified by a database query, 128 patients (first time SIJ RFN procedure only) met the inclusion criteria and were analyzed. Patient demographic, clinical, and procedure-related variables are described in Table 1. Of the included participants, 20.8% were male, and the mean age was 60.4 ± 14.4 years of age. Regarding block protocol: 13.8%, 15.4%, 7.7%, 13.1%, 31.5%, and 18.5% received block type of >79% LBB/LBB, >79% IA/LBB, 50–79% LBB/LBB, 50–79% IA/LBB, >79% LBB, and 50–79% LBB, respectively. Of the 128 patients, 32.8%, 28.1%, and 39.1% received the treatment using cannula type/configuration of 16 g/longitudinal, Trident bipolar/perpendicular, and 18 g quadripolar/perpendicular, respectively. The mean (SD) pre and post-RFN NRS scores were 7.2 (1.7)and 4.1 (2.9) respectively [mean (sd) improvement = 43.1% (34.7)]. The mean (sd) pre and post-RFN PDQQ-S scores were 47.6 (6.9)and 29.0 (17.0) respectively [mean (sd) improvement = 39.6% (33.9)]. respectively. Eighty-seven (66.9%) achieved MCID-2 in NRS, 70 (53.9%) experienced ≥50% NRS reduction, and 65 (50%) achieved ≥17 points decrease in PDQQ (Fig. 3). After adjusting for age, gender, and laterality as well as block type, the odds of achieving MCID-2 in NRS for the 18 g

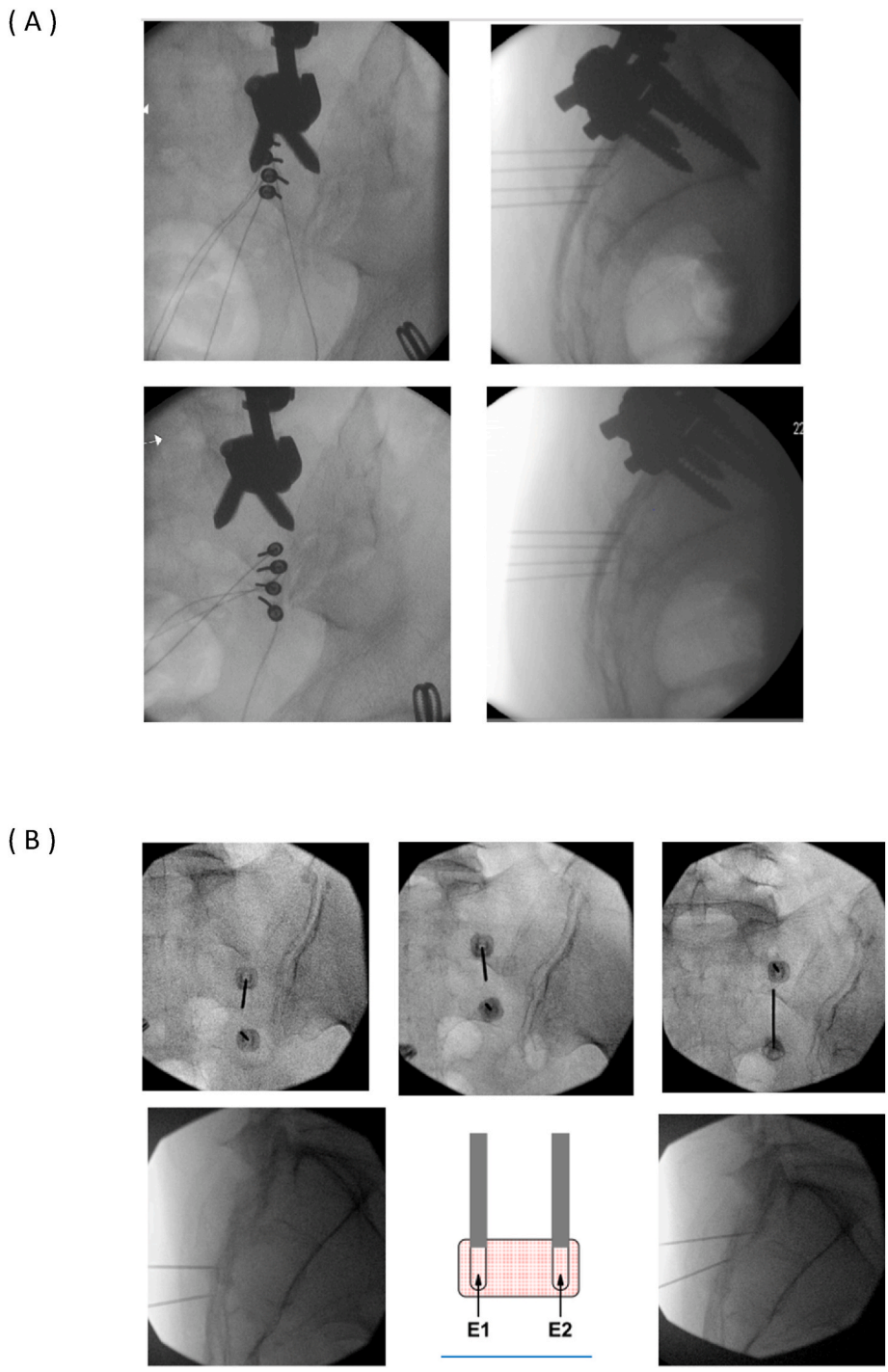

Fig. 2. Demonstration of radiofrequency ablation techqniues as performed under fluoroscopic guidance. (A) 18 g quadripolar/perpendicular, (B) Trident bipolar/perpendicular (C) 16 g/longitudinal.

quadripolar/perpendicular technique was about four times higher than the odds for 16 g/longitudinal technique (OR = 3.91; 95% CI = 1.34–11.43; $p = 0.013$). There was a trend that the 18 g quadripolar/perpendicular technique, compared with 16 g/longitudinal technique, was associated with higher odds of ≥50% NRS reduction (OR = 2.66; 95% CI = 0.98–7.19; $p = 0.054$). Meanwhile, block type was not significantly associated with either outcome variable, after adjusting for needle type, along with the covariates above ($p > 0.05$) (Table 2). Neither block type nor cannula type/RFN technique was significantly associated with ≥17 points decrease in PDQQ ($p > 0.05$). We conducted a sub-analysis focusing solely on the lateral branch block number, percentage pain relief, and treatment success (Table 4). We excluded any intra-articular (IA) responses to examine whether there was an association between treatment success and the use of single LBBs versus dual LBBs, as well as the corresponding percentage of pain reduction (as shown in Table 4). Our findings indicate that there was no statistically significant difference in the success rates of treatment when comparing single LBBs to dual LBBs, regardless of the level of pain relief achieved, except lower success rates (≥50% pain reduction) in individuals who received a single LBB and experienced 50–79% pain reduction (OR 0.39

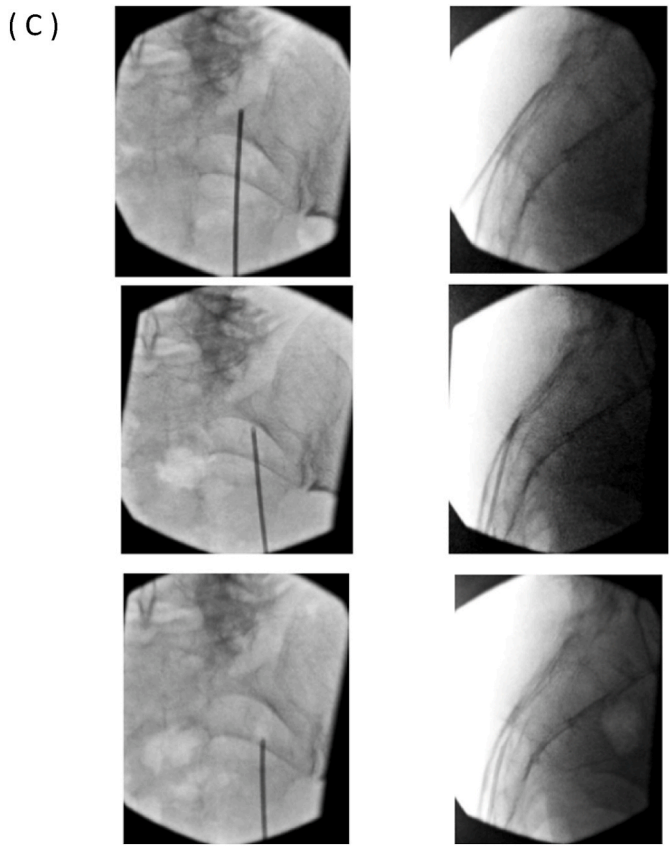

Fig. 2. (*continued*).

[95% CI 0.16, 0.95], p 0.04). Younger age was significantly associated with achieving MCID-2 in NRS, ≥50% NRS reduction, and ≥17 points decrease in PDQQ (p = 0.034, 0.020, and 0.002, respectively). (See Table 3 for extended results).

7. Discussion

Sacroiliac joint radiofrequency neurotomy has been demonstrated to decrease pain intensity and improve disability in patients with SIJ pain [4]. However, there is significant outcome variability within the presently available literature. This variability is likely a result of lack of high-quality studies and heterogeneity in patient selection criteria (including diagnostic blocks) and RFN technique. Our paper aimed to address these discrepancies by assessing the effectiveness of SIJ RFN and predictor variables of success. We present the largest SIJ RFN retrospective cohort database published to date, with a sample size of 128 patients. We have demonstrated that SIJ RFN effectively reduces pain and improves function in most patients at three months post-procedure. Additionally, we found that 18 g cannula quadripolar perpendicular technique and younger age strongly predict treatment success, whereas block selection criteria did not significantly impact procedure outcome.

Regarding the effectiveness of SIJ RFN, there has been previous demonstration in the literature that RFN is effective in providing pain relief for patients with SIJ pain. In 2015 King et al. performed a systematic review on the diagnosis and treatment of sacroiliac joint pain of which, at the time, the evidence behind SIJ RFN was based on 15 studies. They found that the pooled responder rate of SIJ RFN was approxiametely 50% of patients reporting >50% relief at 3 months time post procedure [1]. This was furthered by a systematic review performed by Yang et al., in 2021, in which they found there to be 39 relevant studies in the literature regarding SIJ RFN [15]. They identified that the highest quality evidence available at that time came from two randomized controlled trials [16,17] in which pooled between group comparison revealed treatment with SIJ RFN resulted in an approximately four times greater likelihood of 50% pain reduction at three months post procedure (when compared to sham procedure). Most recently, Young et al. (2022) published a retrospective study comparing the outcomes of SIJ intra articular steroid injections to SIJ lateral branch RFN (n = 19) [3]. They demonstrated that SIJ RFN resulted in a mean preprocedure pain intensity of 5.96/10 dropping to 3.5/10 post-procedure (40.6%). SIJ RFN resulted in longer duration of pain relief (82 days) vs IA steroid injection (38 days). The pain relief experienced by our cohort was very similar (mean = 42.4%), although the pre-RFN pain intensity of our patients tended to be higher (mean = 7.2). Previous to this, Cohen et al. (2009) published a study analyzing the outcome predictors for SIJ RFN in a population of 77 patients [18]. Fifty-two percent of their cohort achieved ≥50% pain relief at six months post SIJ RFN coupled with a positive global perceived effect. This is virtually identical to our cohort at three months post SIJ RFN, 53.9% of whom achieved ≥50% pain relief. Our endpoints also included MCID-2 (>2 point decrease in NRS) and achievement of MCID in the PDQQ [14]. The majority of our patients were successful in achieving all three of our endpoints. The value that our study adds in this respect is that we were able to utilize a larger sample size than has been previously demonstrated, in order to further solidify the importance that this intervention can play in the realm of SIJ complex pain.

Regarding the predictors of SIJ RFN success, we first looked at the impact of pertinent patient demographics (including age, gender, smoking status, employment status, exercise participation and comcomittant mood disturbance through screen with a Beck Depression Inventory). Our population did have a smaller proportion of males (20.8%), (which would be as expected and generalizable given the female predominance in SIJ pain overall), with an average age of 60.4 ± 14.4 years. Of the demographic data that was analyzed, younger age was

Table 1
Demographic information (including co-variates) on patients satisfying criteria for inclusion in study database (N = 128).

Variable	Frequency (%)
Gender	
Male	27 (20.8)
Female	103 (79.2)
Smoker	
Yes	14 (10.8)
No	87 (66.9)
Missing	*29 (22.3)*
Exercise	
Yes	51 (39.2)
No	45 (34.6)
Missing	*34 (26.2)*
Working	
Yes	36 (27.7)
No	43 (33.1)
Retired	25 (19.2)
Missing	*26 (20.0)*
Laterality	
Left	29 (22.3)
Right	45 (34.6)
Bilateral	56 (43.1)
Depression scale	
Subclinical	60 (46.2)
Moderate	3 (2.3)
Missing	*67 (51.5)*
Block type	
>79% LBB/LBB	18 (13.8)
>79% IA/LBB	20 (15.4)
50–79% LBB/LBB	10 (7.7)
50–79% IA/LBB	17 (13.1)
>79% LBB	41 (31.5)
50–79% LBB	24 (18.5)
Needle	
16 g	42 (32.3)
Trident	36 (27.7)
Quad	50 (38.5)
Age in yr (n = 128); mean (SD)	60.4 (14.4)
Body mass index in kg/m^2 (n = 56); mean (SD)	28.5 (6.7)
Pain chronicity in yr (n = 63); mean (SD)	12.7 (14.3)
Pain interference score (n = 66); mean (SD)	36.5 (13.4)
Beck depression score (n = 63); mean (SD)	7.4 (6.0)

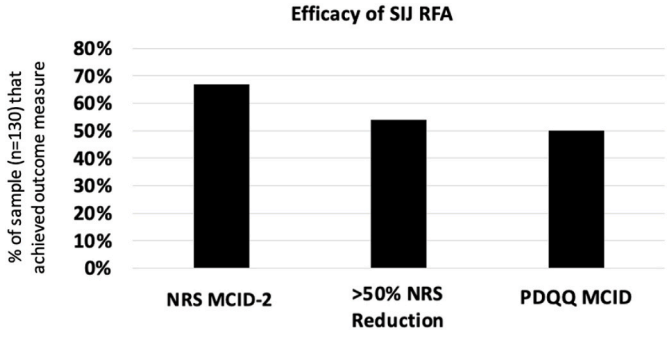

Fig. 3. Efficacy of Sacroiliac Joint Radiofrequency Neurotomy as represented by the proportion of data set that achieved outcome measure.

shown to have a significant association with a positive result on all three outcome measures. Cohen et al. (2009) similarly noted that older age (>65 years) was significantly predictive of failure in response to RFN [18].

Cannula type, number and orientation are also sources of variability in current literature outcomes. This was highlighted by King et al., 's 2015 systematic review, in which they summarize the variability present in the literature in terms of selection criteria and RF technique [1].

Table 2
Diagnostic Block Class as divided based on Block Type and % Pain Relief Response.

Class	Block Type #1	Block Type #2	% Relief	% of Database Population	p-Value (All Outcome Measures
1	LBB	LBB	>79	13.8	>0.05
2	IA	LBB	>79	15.4	>0.05
3	LBB	LBB	50–79	7.7	>0.05
4	IA	LBB	50–79	13.1	>0.05
5	LBB		>79	31.5	>0.05
6	LBB		50–79	18.5	>0.05

IA= Intra Articular Steroid Injection LBB= Lateral Branch Block.
% Relief = NRS scores pre and post block were converted into a % change in pain score.

Roberts et al. (2018) performed a cadaveric study comparing RFN techniques and identified that there was variability in predicted efficacy of the performed techniques in terms of their ability to capture all relevant pain generating structures (importantly the posterior sacral network). Bipolar strip lesions as well as cooled monopolar periforaminal techniques showed greater lateral branch (LB) capture with the palisade and PSN lateral crest techniques being the most effective, whereas monopolar technique and needle placement showed statistically significantly lower LB capture [11]. The recent study by Young et al. cited "variability with interventional approach by individual pain physicians" as a potential confounder [3]. Cohen et al. described that cooled rather than conventional RF was associated with more positive outcomes [18]. A study in 2020 b y Shih et al. compared the efficacy of cooled RF, thermal RF and pulsed RF for treating lumbar facet joint and sacroiliac joint pain, and demonstrated that cooled radiofrequency was the most effective [8]. In our study, we chose to compare the utilization of 16 g/longitudinal [9], 18 g quadripolar/perpendicular, and Trident bipolar/perpendicular techniques, and demonstrated that the odds of achieving MCID-2 in NRS for the 18 g quadripolar/perpendicular technique was about four times higher than the odds for 16 g/longitudinal technique. There was also a trend towards higher odds of ≥50% NRS reduction with the 18 g quadripolar/perpendicular technique. We hypothesize that the superior results with the 18 g quadripolar technique reflect an enhanced ability of the shorter inter-cannula distance to accommodate the undulations of the lateral sacral crest topography. These findings may inform clinician choice in the face of multiplicity of procedural options.

There is currently extensive variability in patient selection criteria for SIJ RFN,.While there are previously validated techniques [19,20], there is currently no gold standard for same and therefore there are multiple techniques utilized in practice at this time. As seen in King et al.'s review article, nearly every included study implemented different patient selection criterion [1]. Yang et al. (2021) further confirmed the presence of significant variability in block paradigm, with intra articular injection utilized most commonly (34/39 studies), only one study utilizing dual lateral branch blocks and two performing single site single depth anesthetic blocks, despite multisite multidepth sacral lateral branch blocks being the only validated procedure [15]. Given the current variability in patient selection and block type protocol we were curious to discover if there was a correlation between block type chosen, block related pain relief magnitude and treatment outcome. Our study is novel and of added value to the literature in that we have the largest study population to date analyzing the differences in selection criteria while controlling for other variables. Our large sample size allows us to perform extensive regression analysis (unlike preceding studies). For our purposes we divided our patient population based on block type and % relief (Table 1), with Class 1 being considered >79% relief on two LBBs and onwards until Class 6 being one LBB of 50–79% relief. Our question in this respect was, is the choice of block type (ie. Intra articular vs LBB) and/or the magnitude of relief experienced following these blocks,

Table 3
Results of logistic regression analysis with the calculations of an odds ratio (OR) and its 95% confidence interval (CI) as subdivided by outcome measures and predictor variables.

Outcome	Predictor	OR	95% CI	*p*
≥2 NRS reduction[a]	Block (vs. > 79% LBB/ LBB)			
	>79% IA/LBB	3.77	0.76, 18.77	0.106
	50–79% LBB/LBB	1.01	0.17, 5.99	0.995
	50–79% IA/LBB	1.41	0.28, 6.96	0.675
	>79% LBB	2.40	0.60, 9.52	0.213
	50–79% LBB	2.63	0.59, 11.77	0.205
	Needle (vs. 16 g)			
	Trident	1.74	0.61, 4.95	0.301
	Quad	3.91	1.34, 11.43	**0.013**
	Age	0.97	0.94, 1.00	**0.034**
	Gender (vs. male)			
	Female	1.81	0.62, 5.22	0.275
	Laterality (vs. right)			
	Left	2.23	0.67, 7.46	0.192
	Bilateral	1.57	0.61, 4.05	0.349
≥50% NRS reduction[b]	Block (vs. > 79% LBB/ LBB)			
	>79% IA/LBB	3.63	0.76, 17.43	0.107
	50–79% LBB/LBB	0.42	0.07, 2.51	0.339
	50–79% IA/LBB	0.94	0.19, 4.52	0.935
	>79% LBB	1.82	0.47, 7.04	0.382
	50–79% LBB	0.87	0.21, 3.69	0.855
	Needle (vs. 16 g)			
	Trident	2.18	0.76, 6.23	0.145
	Quad	2.66	0.98, 7.19	0.054
	Age	0.96	0.93, 0.99	**0.020**
	Gender (vs. male)			
	Female	1.47	0.53, 4.07	0.462
	Laterality (vs. right)			
	Left	3.55	1.12, 11.29	**0.032**
	Bilateral	1.54	0.63, 3.77	0.344
≥17 PDQQ reduction[c]	Block (vs. > 79% LBB/ LBB)			
	>79% IA/LBB	2.22	0.48, 10.24	0.306
	50–79% LBB/LBB	0.61	0.10, 3.64	0.589
	50–79% IA/LBB	1.03	0.21, 5.03	0.973
	>79% LBB	1.35	0.35, 5.18	0.665
	50–79% LBB	1.30	0.31, 5.52	0.721
	Needle (vs. 16 g)			
	Trident	1.35	0.48, 3.78	0.565
	Quad	2.16	0.82, 5.70	0.121
	Age	0.95	0.92, 0.98	**0.002**
	Gender (vs. male)			
	Female	1.28	0.47, 3.52	0.630
	Laterality (vs. right)			
	Left	3.05	1.01, 9.17	**0.047**
	Bilateral	1.88	0.77, 4.63	0.168

OR = odds ratio; CI = 95% confidence interval.
[a] $N = 128$; χ^2 (11) = 21.29; $p = 0.031$; Pseudo $R^2 = 0.131$.
[b] $N = 128$; χ^2 (11) = 24.19; $p = 0.012$; Pseudo $R^2 = 0.137$.
[c] $N = 128$; χ^2 (11) = 20.53; $p = 0.039$; Pseudo $R^2 = 0.116$.

predictive of eventual RFN outcome. Interestingly, we found that block type was not significantly associated with any of the outcome variables. These results hold the possibility of ground breaking significance in terms of practice patterns, given that at present time there is significant emphasis placed on strict block-based selection criterion for this patient population. Of perhaps most significance to note in this study is the fact there we did not find any difference in eventual RFN success in our populations treated with the strictest selection (dual LBB with >80% pain reduction) versus those with combinations of LBB with intra articular injections versus lower demonstrated relief or single versus

Table 4
Sub-analysis including only lateral branch block response as selection criteria.

Outcome	Predictor	OR	95% CI	*p*
≥2 NRS reduction[a]	>79% LBB			
	50–79% LBB	0.71	0.27, 1.85	0.485
	>79% LBB/LBB	0.35	0.10, 1.31	0.119
	50–79% LBB/LBB	0.38	0.07, 1.95	0.244
≥50% NRS reduction[b]	>79% LBB			
	50–79% LBB	0.39	0.16, 0.95	**0.039**
	>79% LBB/LBB	0.44	0.12, 1.60	0.212
	50–79% LBB/LBB	0.20	0.04, 1.00	0.051
≥17 PDQQ reduction[c]	>79% LBB			
	50–79% LBB	0.73	0.30, 1.77	0.488
	>79% LBB/LBB	0.63	0.17, 2.26	0.475
	50–79% LBB/LBB	0.41	0.08, 2.00	0.270

OR = odds ratio; CI = 95% confidence interval; LBB = single lateral branch block; LBB/LBB = dual lateral branch block; PDQQ = Patient Disability Quality of Life Questionnaire.
[a] $N = 128$; χ^2 (9) = 20.14; $p = 0.017$; Pseudo $R^2 = 0.124$.
[b] $N = 128$; χ^2 (9) = 23.02; $p = 0.006$; Pseudo $R^2 = 0.130$.
[c] $N = 128$; χ^2 (9) = 19.77; $p = 0.019$; Pseudo $R^2 = 0.111$.

double block protocols. These results suggest there are likely other yet to be elucidated predictor factors at play that are more robust than block type and response. The role of SIJ intra articular injection as a diagnostic/prognostic test for SIJ pain and RF success is controversial. Our data suggests that adding an IA injection to a single block does not affect results of SIJ RF, though we acknowledge that inclusion of intra-articular blocks in two of the six block classes (Class 2 and Class 4) is controversial given what is known about the anterior innervation of the synovial portion of the SIJ complex [18]. However, at worst, the intra-articular blocks could be considered irrelevant and can be disregarded, thus making block Class 2 and Class 4 patients into a single LBB category (Class 5 and Class 6 respectively), as was explored in our sub analysis (Table 4). Our sub-analysis revealed a potential decrease in treatment success rates among individuals who were chosen for a single lateral branch block (LBB) and experienced a pain reduction of 50–79%, in comparison to those who achieved pain reductions exceeding 79% after a single LBB, or those who underwent dual LBBs and achieved a pain reduction of over 50%. However, it is important to note that this association was only observed in pain reductions exceeding 50% at the 3-months and did not demonstrate significance in the NRS and PDQQ MCIDs. Consequently, further research is necessary to explore and confirm these findings. Beyond this, our findings of this sub-analysis otherwise indicated that there was no statistically significant difference in the success rates of treatment when comparing single LBBs to dual LBBs regardless of the level of pain relief achieved.

Our study is a valuable addition to the presently available literature analyzing SIJ radiofrequency neurotomy and predictors of success. However, there are limitations to our study, one of which is the single-arm retrospective cohort design. The lack of a comparison/control group limits our ability to definitively substantiate the efficacy of this intervention and control for confounders. Regarding block selection criteria utilized within our study, we acknowledge as a major limitation that there is significant variability to which patients were selected, and within the block techniques utilized. Of particular note, we acknowledge a limitation being that within the presently available literature there has only been one validated fluoroscopically guided injection technique to have thus far shown validity for the diagnosis of SI joint dorsal ligament pain, that being, the utilization of multi site multi depth SLBBs [19]. Our study did not utilize this technique, therefore acknowledge this as a limitation, though do draw reference to the cadaveric study of Roberts et al. (2014) whom demonstrated that the lateral branch nerves run exclusively along the periosteum, which suggests that multisite single depth (periosteal) would effectively target the lateral branch nerves [2]. This hypothesis is yet to be validated. This variability in selection

criteria is mirrored within the available literature [1,15]. Further in regard to our patient selection criteria, we chose to include patients that achieved >50% relief at any time point within their 6 h post procedure pain diary. This should be considered as a potential limitation of our study, though, we do draw reference to the work of Schneider et al. (2022) whom investigated the patient perceived duration of effect of lidocaine versus bupivacaine in medial branch blocks, and identified significant variability in duration of perceived effect, suggesting reconsideration of emphasis on duration of relief from specific anesthetics for diagnostic utility [21] Regarding the radiofrequency ablation technique, we acknowledge that another limitation of our study is utilizing a variety of procedural techniques. In particular, our 16 g longitudinal protocol utilized an 'ultrasound assisted technique' which is somewhat novel and not commonly utilized, though does have basis within previously published literature [9,20]. In particular, we reference the available literature by Finlayson et al. (2017) and Loh et al. (2022) who both demonstrated ultrasound guided radiofrequency ablation approaches for the SIJ. Significant improvements in pain, disability and quality-of-life were documented. Additionally, comparable block and RFA effects, shorter performance time, fewer needle passes and lower risk of vascular breach were documented when compared to fluoroscopy [10,20]. The variability within our selection criteria and procedural technique may have possible contribution to our modest outcomes. On the other hand, a robust sample size allowed meaningful evaluation of the various block (n = 6) and SIJ RFA (n = 3) protocols and their relationship to SIJ RFA outcome. In the statistical analysis, when block type or SIJ RFA procedure type was not the independent variable of interest, the varied block/procedure types were adjusted for. Whereas prior research evaluated the diagnostic/predictive capacity of different block types to suppress iatrogenically induced ligamentous or capsular pain to better understand the optimal block technique for SIJ RFN (construct validity), we evaluated the relationship between various block techniques and the ultimate outcome of interest - SIJ RFN (criterion validity). Lastly, we acknowledge that the short follow up time frame of our study - with outcome measures of our study being analyzed at only 3 months post intervention – is a definite limitation of our study. That said, King et al. systematic review showed that SIJ RFN outcomes were best at 3 months, with 50% of patients achieving ~50% pain relief [1]. Lumbar and cervical RFA outcomes also peak improvements at 3 months with decreasing benefits with time as per Burnham & Yasui (2007) [22]. Nonetheless, we cannot yet predict the responder rate of SIJ RFN beyond this time point.

In the future, it will be imperative to further establish the presence of posterior SIJ complex pain with relief by multisite lateral branch blocks. This needs to be further elucidated through randomized controlled trials with sham comparison to substantiate the efficacy of this intervention. Additionally, we had initially collected extensive demographic data on our patient population, though not all patients had their initial intake clinical examination completed through our clinic and as a result had missing demographic data points. This resulted in us being unable to glean meaningful analysis for many of these predictive variables. As a future direction, we hope to explore additional demographic factors (i.e., BMI, smoking status, employment status, duration of pain (years), psychiatric comorbidity etc.) and their impact on eventual treatment success.

8. Conclusion

SIJ RFN effectively reduces pain and improves function in most patients at three months post-procedure. 18 g quadripolar/perpendicular technique and younger age predict SIJ RFN treatment success, whereas block type does not.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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