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Cryoneurolysis of Sacral Lateral Branches for Chronic Sacroiliac Joint Pain: A Multicenter Retrospective Cohort Study

Authors' Contribution:

Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF 1-3 **Paweł Gogol**
DF 4 **Małgorzata Gierczak**
C 1,2 **Robert Szczepaniak**
C 5 **Rafał Pasztaleniec**
B 1 **Rafał Wiśniewski**
E 6 **Małgorzata Malec-Milewska**
BDF 3 **Rafał Staszkiwicz**
CE 7 **Beniamin Oskar Grabarek**
E 8 **Michał Sobstyl**

1 Neurolocus Pain Management Centre, Warsaw, Poland
2 Pain Treatment Clinic, Our Lady of Perpetual Help Hospital in Wołomin, Wołomin, Poland
3 Department of Neurosurgery, Faculty of Medicine, Academy of Silesia, Katowice, Poland
4 Osteo Clinic, Warsaw, Poland
5 Pain Medicine Centre, Piła, Poland
6 Department of Anesthesiology and Intensive Care, Centre of Postgraduate Medical Education, Warsaw, Poland
7 Collegium Medicum, WSB University, Dąbrowa Górnicza, Poland
8 Department of Neurosurgery, Institute of Psychiatry and Neurology, Warsaw, Poland

Corresponding Author: Paweł Gogol, Neurolocus Pain Management Centre, Olszynki Grochowskiej 11/15 lok. U3, 04-281 Warsaw, Poland, Phone: +48 608 388 207, e-mail: drpawelgogol@gmailcom
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Background: Chronic sacroiliac joint (SIJ) pain is a common cause of chronic low back pain and disability. Cryoneurolysis targeting the sacral lateral branches has emerged as a minimally invasive treatment option for SIJ-mediated pain.

Material/Methods: This multicenter retrospective cohort study included 107 patients with chronic SIJ-mediated pain confirmed by a diagnostic SIJ block that achieved at least 50% pain relief. All patients underwent cryoneurolysis of the lateral branches of the L5 and S1 to S3 dorsal rami. Pain intensity was assessed using the Numeric Rating Scale (NRS) and Visual Analog Scale (VAS); functional disability was evaluated using the Oswestry Disability Index (ODI). Outcomes were analyzed at baseline and at 3 and 6 months post-procedure.

Results: Significant reductions in pain intensity were observed at both follow-up time points ($P < 0.001$). Mean NRS scores decreased from 7.4 ± 1.1 at baseline to 3.6 ± 1.5 at 3 months and 4.2 ± 1.7 at 6 months. Mean VAS scores decreased from 74 ± 12 mm at baseline to 38 ± 15 mm and 45 ± 17 mm, respectively. Mean ODI scores improved from $42 \pm 9\%$ at baseline to $24 \pm 10\%$ at 3 months and $28 \pm 11\%$ at 6 months. At least 50% pain reduction was achieved in 59.8% of patients at 3 months and 48.6% at 6 months. No serious adverse events were observed.

Conclusions: Cryoneurolysis offers a safe and potentially effective minimally invasive treatment for chronic SIJ-mediated pain, providing short- to mid-term pain relief and functional improvement.

Keywords: **Sacroiliac Joint • Pain Management • Sacroiliac Joint • Low Back Pain • Cryosurgery • Sacrum • Retrospective Studies • Neuroanesthesia**

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Introduction

Chronic low back pain, a leading cause of disability worldwide, imposes a substantial socioeconomic burden due to reduced functional capacity, increased healthcare utilization, and loss of productivity. The lifetime prevalence of low back pain exceeds 60% to 80%; approximately 20% of affected individuals develop chronic symptoms that persist for longer than 3 months [1,2]. Among various anatomical structures implicated in chronic low back pain, the sacroiliac joint (SIJ) has been identified as a primary pain generator in approximately 15% to 30% of patients, particularly those with persistent pain after lumbar spine surgery, degenerative spinal disease, or altered biomechanical loading of the pelvis and lumbar spine [3].

The SIJ is a complex diarthrodial structure comprising an anterior synovial component and posterior ligamentous complex, both of which are richly innervated and capable of generating nociceptive input. Anatomical and histological investigations have demonstrated that the posterior sacroiliac region primarily receives sensory innervation from the lateral branches of the dorsal rami of the L4 to L5 and S1 to S3 spinal nerves, whereas the anterior joint capsule receives variable contributions from the ventral rami and lumbosacral trunk [4,5]. This complex and highly variable neural architecture contributes to diagnostic challenges and may partially explain the heterogeneity of clinical outcomes after targeted interventional procedures [6].

Management of SIJ-mediated pain typically begins with conservative therapies, including physical therapy, pharmacologic treatment, and activity modification [7]. However, a substantial proportion of patients fail to achieve adequate long-term pain control with conservative management alone. Image-guided intra-articular injections of local anesthetics and corticosteroids may provide diagnostic confirmation and temporary symptom relief, but their therapeutic benefit is often limited in duration and may require repeated administration [8]. Radiofrequency ablation of the sacral lateral branches has emerged as a minimally invasive neuroablative technique that can provide longer-lasting analgesia; however, clinical outcomes remain variable due to anatomical variability, lesion geometry, and technical factors that influence nerve capture [9,10].

Cryoneurolysis represents an alternative percutaneous neuroablative approach that produces controlled, reversible nerve injury through cryogenic axonal disruption while preserving the structural integrity of surrounding connective tissue. This mechanism, consistent with axonotmesis and subsequent Wallerian degeneration, allows temporary interruption of nociceptive transmission while maintaining the potential for nerve regeneration over time [11,12]. Unlike thermal neuroablation, cryoneurolysis produces a circumferential cryolesion (“ice ball”)

capable of encompassing small and anatomically variable neural branches, thereby potentially improving denervation coverage. Furthermore, cryoneurolysis avoids thermal tissue destruction and may reduce the risk of neuroma formation and post-denervation neuritis compared with heat-based techniques [13].

Despite its established role in the management of various peripheral pain syndromes, clinical data evaluating the effectiveness of cryoneurolysis specifically for SIJ-mediated pain remain limited. Larger multicenter studies are needed to assess analgesic efficacy and functional outcomes in carefully selected patients with diagnostically confirmed SIJ pain [14,15].

Therefore, the aim of this multicenter observational study was to evaluate the effectiveness and safety of SIJ cryoneurolysis in patients with chronic SIJ-mediated pain confirmed by diagnostic blockade. We hypothesized that cryoneurolysis targeting the lateral branches of the L5 and S1 to S3 dorsal rami would result in significant reductions in pain intensity, improved functional disability, and decreased analgesic consumption at mid-term follow-up.

Material and Methods

Study Design and Setting

This multicenter retrospective cohort study was conducted to evaluate the effectiveness and safety of cryoneurolysis targeting the sacral lateral branches in patients with chronic SIJ-mediated pain. The analysis included patients treated between January 2021 and December 2025 at 2 specialized interventional pain management centers in Poland: Neurolocus Pain Management Centre (Warsaw) and Pain Medicine Centre (Piła). All procedures were performed by experienced interventional pain physicians with extensive expertise in fluoroscopy-guided spinal interventions.

The study was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Due to the retrospective nature of the study, prospective registration was not required. All patients had previously provided written informed consent for the interventional procedure, as well as the use of anonymized clinical data for research purposes. The study protocol for retrospective data analysis was approved by the Bioethical Committee of the Regional Medical Chamber in Kraków (approval No. 89/KBL/OIL/2026, dated March 10, 2026). Strict data anonymization and confidentiality were maintained throughout the study.

Clinical treatment and follow-up were completed by December 2025. Retrospective data verification, anonymization, and statistical analyses were conducted after completion of patient

follow-up and approval by the ethics committee, prior to manuscript submission in March 2026.

Patient Population

In total, 107 consecutive patients diagnosed with SIJ-mediated pain were included in the study. Consecutive enrollment was used to reduce selection bias and enhance the representativeness of the treated population. The study cohort comprised 56 women (52.3%) and 51 men (47.7%), ranging in age from 29 to 71 years.

All patients presented with chronic low back pain persisting for at least 6 months and demonstrated clinical features consistent with SIJ-mediated pain. Eligibility required a comprehensive diagnostic evaluation confirming the SIJ as the primary pain generator. Patients were required to have a baseline pain intensity of at least 5 on the Numeric Rating Scale (NRS) and to have conservative management (eg, pharmacologic treatment, physical therapy, and activity modification) failure for a minimum of 3 months.

A mandatory inclusion criterion was a positive response to a diagnostic SIJ block, defined as a reduction in pain intensity of at least 50%. Patients were excluded if they had acute or progressive radiculopathy, imaging-confirmed nerve root compression requiring surgical intervention, inflammatory sacroiliitis, prior SIJ fusion, coagulation disorders precluding interventional procedures, active infection, pregnancy, or severe systemic disease that could interfere with treatment outcomes or follow-up.

Diagnostic Confirmation of SIJ Pain

The diagnosis of SIJ-mediated pain was established using a standardized multimodal diagnostic protocol that encompassed clinical evaluation, physical examination, imaging, and confirmatory diagnostic blockade. Clinical assessment included a detailed evaluation of pain location, radiation patterns, and aggravating factors characteristic of SIJ pathology.

Physical examination incorporated a battery of standardized SIJ provocative maneuvers, including the FABER (Patrick's) test, Gaenslen's test, sacral thrust test, and compression and distraction tests, all performed in accordance with established clinical protocols.

Magnetic resonance imaging of the lumbar spine and SIJs was performed in all patients to exclude alternative structural causes of pain, such as lumbar disc herniation, spinal canal stenosis, nerve root compression, or inflammatory sacroiliitis.

Diagnostic confirmation was achieved using a single fluoroscopy-guided intra-articular SIJ block performed under sterile conditions. A 22-gauge spinal needle was advanced into the joint space under fluoroscopic guidance. Correct needle placement was verified by injection of a small volume of nonionic contrast medium confirming intra-articular positioning. Subsequently, 1.5 to 2.0 mL of 2% lidocaine were administered. Pain intensity was assessed using the NRS immediately before injection and again 30 to 60 minutes after the procedure. A pain intensity reduction of at least 50% was considered diagnostic of SIJ-mediated pain and was required for study inclusion.

Although dual comparative blocks are recommended by some interventional pain guidelines to improve diagnostic specificity, a single fluoroscopy-guided intra-articular block was used in this retrospective study, in accordance with routine clinical practice at the participating centers.

Cryoneurolysis Equipment

Cryoneurolysis was performed using the Cryoflex A13 cryosurgical system (Metrum Cryoflex, Poland), which uses pressurized carbon dioxide as the cryogenic agent. The system operates based on the Joule-Thomson effect, resulting in rapid temperature reduction at the probe tip during gas expansion. The cryoprobe achieved a target temperature of approximately -78 °C, sufficient to induce controlled cryogenic axonotmesis of peripheral nerve structures.

The mechanism of action involves axonotmesis, characterized by disruption of axonal and myelin integrity while preserving the connective tissue framework of the nerve, including the endoneurium, perineurium, and epineurium. This structural preservation allows subsequent axonal regeneration and reversible interruption of nociceptive signal transmission.

Procedural Technique

All procedures were performed in dedicated interventional suites under strict aseptic conditions using continuous fluoroscopic guidance with a mobile C-arm imaging system. Patients were positioned prone. Local anesthesia was achieved through infiltration of 2% lidocaine into the skin, subcutaneous tissue, and deeper tissue layers along the planned trajectory of the cryoprobe. No sedation or general anesthesia was administered.

Under fluoroscopic guidance, the cryoprobe was advanced to target the lateral branches of the dorsal rami of L5 and S1 to S3, which provide sensory innervation to the posterior SIJ complex. Probe positioning was guided using anteroposterior and oblique fluoroscopic projections, with placement adjacent to the osseous surface between the sacral foramina and the SIJ (**Figure 1**).

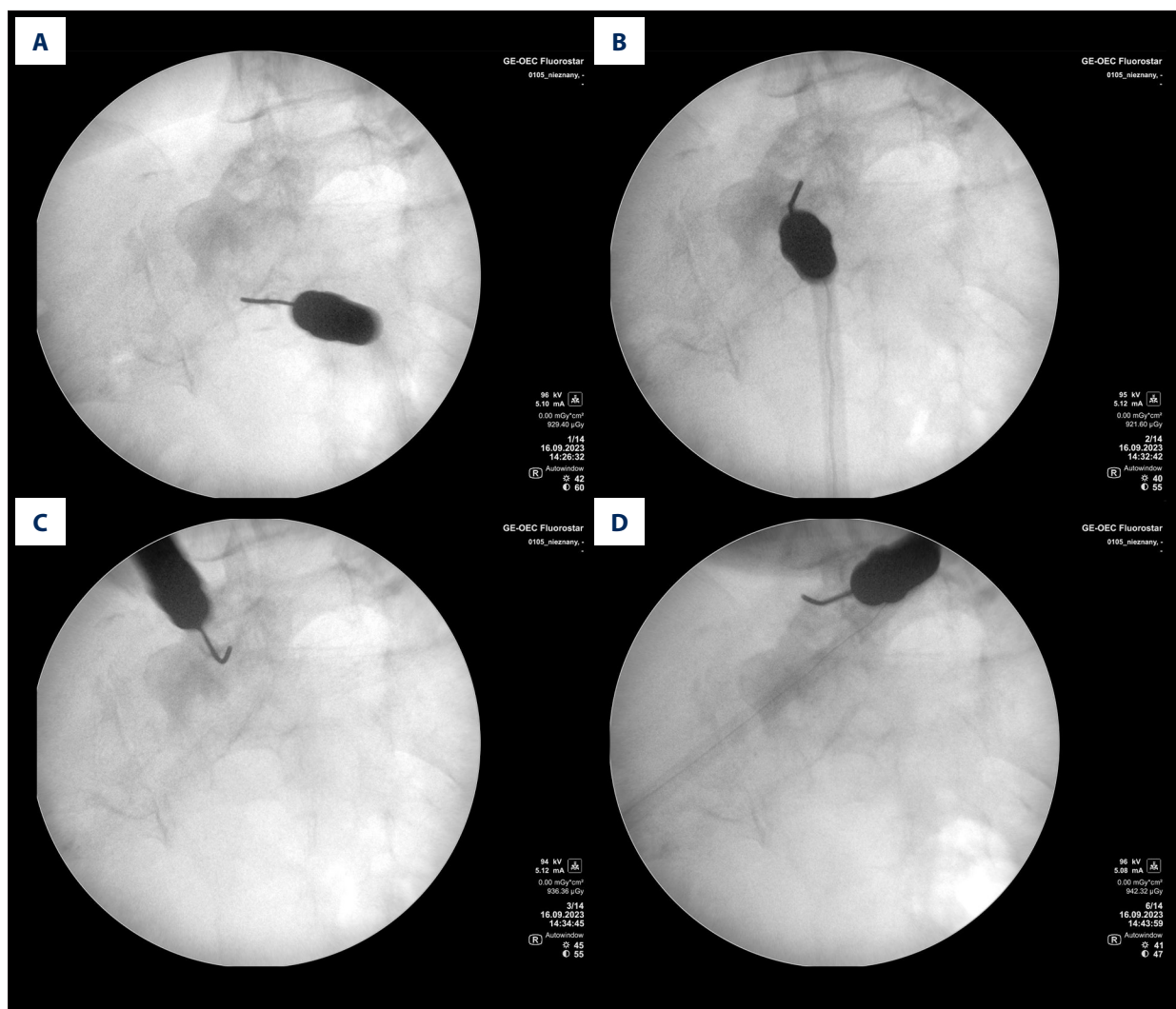


Figure 1. Representative fluoroscopic images demonstrating cryoprobe placement during sacroiliac joint cryoneurolysis targeting the lateral branches of the L5 dorsal ramus and S1-S3 sacral lateral branches. (A) Anteroposterior fluoroscopic projection demonstrating probe positioning adjacent to the sacral foramina. (B) Fluoroscopic visualization of cryoprobe advancement toward the posterior sacroiliac joint complex. (C) Oblique projection illustrating probe orientation relative to the lateral sacral border and targeted neural structures. (D) Final fluoroscopic confirmation of cryoprobe placement prior to cryoapplication.

Motor stimulation testing was performed at 2 Hz before cryoapplication to confirm the absence of proximity to motor nerve fibers. Cryoapplication was initiated only when no visible motor response or muscle contraction was elicited at stimulation thresholds up to 2 V. Multiple cryolesions were created along the course of the targeted nerves, typically resulting in 6 to 7 lesions per treated side. Each lesion consisted of a 120-second freeze cycle at a target temperature of approximately -78°C , followed by passive thawing. Repeated freeze-thaw cycles were used to maximize lesion size and ensure adequate neural coverage. All procedures were performed on an outpatient basis.

Post-Procedural Management and Follow-up

Following the procedure, patients were monitored for immediate complications and discharged on the same day. Patients were informed that analgesic effects might develop gradually over several days due to cryoneurolysis-induced axonal degeneration.

No corticosteroids were administered during or after the procedure to avoid confounding treatment outcomes. Follow-up assessments were conducted at 3 and 6 months after the procedure.

Table 1. Baseline demographic and clinical characteristics of the study cohort.

Characteristic	Value
Number of patients	107
Female, n (%)	56 (52.3%)
Male, n (%)	51 (47.7%)
Age, years (mean ± SD)	53.8 ± 9.6
Age range, years	29-71
Symptom duration, months (mean ± SD)	18.6 ± 7.9
Right-sided procedure, n (%)	58 (54.2%)
Left-sided procedure, n (%)	49 (45.8%)
Positive diagnostic block, n (%)	107 (100%)
Baseline NRS (mean ± SD)	7.4 ± 1.1
Baseline VAS, mm (mean ± SD)	74 ± 12
Baseline ODI,% (mean ± SD)	42 ± 9

Abbreviations: NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; SD, standard deviation; VAS, Visual Analog Scale.

Outcome Measures

The primary outcome measure was the change in pain intensity assessed using the NRS. Pain intensity was recorded at baseline and at each follow-up visit.

Secondary outcome measures included functional disability assessed using the Oswestry Disability Index (ODI) and changes in analgesic consumption. Analgesic use was categorized as nonsteroidal anti-inflammatory drugs (NSAIDs), combination analgesics, or opioid-containing medications.

Treatment response was additionally evaluated via responder analysis based on the proportion of patients achieving at least 50% reduction in pain intensity relative to baseline values.

Safety Assessment

Safety assessment encompassed systematic monitoring and documentation of all procedural and post-procedural adverse events, including bleeding, infection, neurological deficits, procedure-related pain, and sensory disturbances. Adverse events were recorded and classified according to severity and duration.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation. Data distribution normality was assessed using the Shapiro-Wilk test. Changes in pain intensity and functional disability over time were analyzed using repeated-measures analysis of variance (ANOVA) with Bonferroni-adjusted post hoc pairwise comparisons among baseline, 3-month, and 6-month

assessments. Effect sizes for primary outcome measures were calculated using Cohen's *d*.

Categorical variables, including analgesic use and responder rates, were compared using the chi-square test. Treatment responder rates were calculated as the proportion of patients achieving at least 50% reduction in pain intensity relative to baseline values.

P-values < 0.05 were considered statistically significant. Statistical analyses were performed using StatPlus software (AnalystSoft Inc., Brandon, FL, USA).

Results

Patient Characteristics

In total, 107 consecutive patients were included in the analysis; all completed the 6-month follow-up, and none were lost to follow-up. Baseline demographic and clinical characteristics are presented in **Table 1**. The study population was balanced with respect to sex distribution and consisted of patients with longstanding symptoms, high baseline pain intensity, and moderate to severe functional impairment. All patients demonstrated a positive response to the diagnostic SIJ block, confirming the SIJ as the primary pain generator.

Pain and Functional Outcomes

Cryoneurolysis was associated with significant and clinically meaningful reductions in pain intensity and functional disability,

Table 2. Changes in pain intensity outcomes after sacroiliac joint cryoneurolysis.

Time point	NRS (mean ± SD)	Change from baseline	VAS (mm, mean ± SD)	Change from baseline	Bonferroni-adjusted pairwise comparisons
Baseline	7.4 ± 1.1	—	74 ± 12	—	—
3 months	3.6 ± 1.5	-3.8 (-51.4%)	38 ± 15	-36 (-48.6%)	Baseline vs 3 months: $P < 0.001$
6 months	4.2 ± 1.7	-3.2 (-43.2%)	45 ± 17	-29 (-39.2%)	Baseline vs 6 months: $P < 0.001$; 3 vs 6 months: $P = 0.021$

Repeated-measures ANOVA demonstrated a significant effect of time on both NRS and VAS outcomes ($P < 0.001$). The effect size for NRS reduction at 3 months was large (Cohen's $d = 2.9$). Percentage change represents the relative reduction compared with baseline values. Abbreviations: NRS, Numeric Rating Scale; SD, standard deviation; VAS, Visual Analog Scale.

Table 3. Changes in functional disability outcomes assessed using the Oswestry Disability Index.

Time point	ODI (% mean ± SD)	Change from baseline	Relative improvement	Bonferroni-adjusted pairwise comparisons
Baseline	42 ± 9	—	—	—
3 months	24 ± 10	-18	42.9%	Baseline vs 3 months: $P < 0.001$
6 months	28 ± 11	-14	33.3%	Baseline vs 6 months: $P < 0.001$; 3 vs 6 months: $P = 0.034$

Repeated-measures ANOVA demonstrated a significant effect of time on ODI scores ($P < 0.001$). Relative improvement is expressed as the percentage reduction from baseline values. Abbreviations: ODI, Oswestry Disability Index; SD, standard deviation.

Table 4. Responder analysis according to degree of pain reduction.

Outcome	3 Months	6 Months	P-value*
≥ 50% pain reduction	64/107 (59.8%)	52/107 (48.6%)	0.041
≥ 30% pain reduction	81/107 (75.7%)	68/107 (63.6%)	0.032
NRS ≤ 2	20/107 (18.7%)	13/107 (12.1%)	0.18

Values are presented as number/total number (%). * Comparison between 3- and 6-month follow-up assessments. Abbreviation: NRS, Numeric Rating Scale.

as presented in **Tables 2 and 3**. Pain intensity substantially decreased at 3 months and remained significantly lower at 6 months than at baseline, although partial attenuation of the effect was observed over time.

Repeated-measures ANOVA demonstrated a significant effect of time on both pain intensity and disability ($P < 0.001$ for both outcomes). Bonferroni-adjusted post hoc analysis demonstrated significant differences between baseline and the 3-month follow-up, as well as between baseline and the 6-month follow-up (both $P < 0.001$). A modest but statistically significant increase in pain intensity and disability was also observed between 3 and 6 months ($P < 0.05$), reflecting partial attenuation of treatment-associated effects over time. The effect size for reduction in NRS scores at 3 months was large (Cohen's

$d = 2.9$), indicating substantial clinical improvement. The magnitude of pain reduction exceeded 50% at 3 months and remained greater than 40% at 6 months (**Table 2**).

Functional outcomes followed a similar trajectory, with the greatest improvement observed at 3 months and sustained benefit at 6 months. Mean ODI scores decreased from 42% at baseline to 24% at 3 months and 28% at 6 months, corresponding to relative improvements of 42.9% and 33.3%, respectively (**Table 3**).

Responder Analysis

Responder analysis demonstrated that a substantial proportion of patients achieved clinically meaningful pain relief (**Table 4**).

Table 5. Changes in analgesic medication use during follow-up.

Medication type	Baseline	3 Months	6 Months	Relative reduction (6 months)	P-value*
NSAIDs	94 (87.9%)	41 (38.3%)	50 (46.7%)	-46.8%	< 0.001
Opioid-containing analgesics	63 (58.9%)	26 (24.3%)	39 (36.4%)	-38.1%	0.002

Values are presented as the number (%) of patients using each medication category. * Comparison between baseline and the 6-month follow-up assessment. Abbreviation: NSAIDs, nonsteroidal anti-inflammatory drugs.

Table 6. Procedural characteristics and technical outcomes of cryoneurolysis.

Parameter	Value
Technical success rate, n (%)	107 (100%)
Number of cryolesions (mean ± SD)	6.4 ± 0.8
Procedure duration, minutes (mean ± SD)	32.5 ± 8.7
Technical failures, n (%)	0 (0%)

Abbreviation: SD, standard deviation.

At 3 months, 59.8% of patients achieved at least 50% pain reduction, and 48.6% maintained this level of improvement at 6 months. A larger proportion of patients achieved at least 30% pain reduction at both time points, indicating sustained therapeutic benefit in most cases.

Additionally, complete or near-complete pain control (NRS ≤ 2) was observed in 18.7% of patients at 3 months and 12.1% at 6 months (Table 4).

Analgesic Use and Procedural Characteristics

Treatment was associated with a substantial reduction in analgesic consumption, including both NSAIDs and opioid-containing medications (Table 5). The proportion of patients

using NSAIDs decreased from 87.9% at baseline to 46.7% at 6 months. Similarly, opioid use declined from 58.9% to 36.4%, with a substantial proportion of patients discontinuing opioid therapy during follow-up. A modest increase in NSAID use was observed between the 3- and 6-month follow-up assessments, paralleling the partial increase in pain intensity observed during the same period.

Procedural success was achieved in all patients, without technical failures. Procedural parameters were consistent across cases, with a mean of 6.4 cryolesions per procedure and mean procedure duration of 32.5 minutes (Table 6).

Safety and Procedural Tolerability

Cryoneurolysis was well tolerated; no serious adverse events, infections, or permanent neurological deficits were observed (Table 7). Minor complications were infrequent, transient, and self-limited. The most common adverse events were procedural pain (11.2%) and transient paresthesia (6.5%), both of which resolved without intervention.

Subgroup Analysis

Exploratory subgroup analyses demonstrated generally consistent treatment-associated outcomes across sex, age, and baseline pain severity, as detailed in Tables 8-10.

Table 7. Procedural safety profile and treatment-related adverse events.

Complication	n (%)	Outcome
Local hematoma	3 (2.8%)	Resolved spontaneously
Transient paresthesia	7 (6.5%)	Resolved spontaneously
Procedural pain	12 (11.2%)	Self-limited
Temporary motor weakness	2 (1.9%)	Resolved within hours
Infection	0 (0%)	—
Permanent neurological deficit	0 (0%)	—

All adverse events were transient and resolved without long-term sequelae.

Table 8. Exploratory subgroup analysis of treatment outcomes according to sex.

Outcome	Female (n = 56)	Male (n = 51)	P-value
Baseline NRS	7.5 ± 1.1	7.3 ± 1.0	0.38
NRS reduction (3 months)	-3.9 ± 1.4	-3.7 ± 1.6	0.52
NRS reduction (6 months)	-3.3 ± 1.7	-3.1 ± 1.6	0.61
Responder rate (6 months)	50.0%	47.1%	0.76

Values are presented as mean ± SD or percentage. *P*-values indicate between-group comparisons. Abbreviations: NRS, Numeric Rating Scale; SD, standard deviation.

Table 9. Exploratory subgroup analysis according to age group.

Outcome	< 55 years (n = 58)	≥ 55 years (n = 49)	P-value
Baseline NRS	7.3 ± 1.1	7.5 ± 1.0	0.41
NRS reduction (6 months)	-3.5 ± 1.6	-2.9 ± 1.7	0.048
Responder rate (6 months)	53.4%	42.9%	0.039

Values are presented as mean ± SD or percentage. *P*-values indicate between-group comparisons. Subgroup analyses were exploratory and not adjusted for multiple comparisons. Abbreviations: NRS, Numeric Rating Scale; SD, standard deviation.

Table 10. Exploratory subgroup analysis according to baseline pain severity.

Outcome	NRS 5-6 (n = 28)	NRS 7-8 (n = 52)	NRS 9-10 (n = 27)	P-value
Baseline NRS	5.8 ± 0.4	7.4 ± 0.5	9.1 ± 0.6	—
Reduction at 6 months	-2.5 ± 1.2	-3.3 ± 1.6	-4.1 ± 1.9	0.012
Responder rate	42.9%	50.0%	51.9%	0.44

Values are presented as mean ± SD or percentage. *P*-values indicate between-group comparisons. Subgroup analyses were exploratory and should be interpreted cautiously. Abbreviations: NRS, Numeric Rating Scale; SD, standard deviation.

No statistically significant differences in treatment response were observed between female and male patients (Table 8). Baseline pain intensity, magnitude of pain reduction at both 3 and 6 months, and responder rates were comparable between sexes (all *P* > 0.05), suggesting similar treatment-associated outcomes in women and men.

Age-stratified analysis revealed that patients younger than 55 years experienced slightly greater improvement at 6 months relative to older patients (Table 9). Specifically, younger patients demonstrated a greater reduction in NRS scores (-3.5 vs -2.9; *P* = 0.048) and higher responder rates (53.4% vs 42.9%; *P* = 0.039). Although statistically significant, these differences were modest in magnitude.

Analysis according to baseline pain severity showed that patients with higher initial pain intensity achieved greater absolute reductions in pain at 6 months (Table 10). Patients with baseline NRS scores of 9 to 10 demonstrated the greatest improvement (-4.1 ± 1.9), compared with those exhibiting

moderate pain (-3.3 ± 1.6) and lower baseline pain (-2.5 ± 1.2; *P* = 0.012). However, responder rates were similar across all severity groups (*P* = 0.44), suggesting comparable relative treatment effectiveness.

Overall, these findings suggest that cryoneurolysis is associated with clinically meaningful benefit across diverse patient subgroups. However, these subgroup analyses should be interpreted cautiously because they were exploratory, not pre-specified, and potentially underpowered.

Discussion

The present multicenter observational study demonstrated that cryoneurolysis targeting the sacral lateral branches was associated with significant and clinically meaningful reductions in pain intensity, improved functional disability, and reduced analgesic consumption in patients with chronic SIJ-mediated pain. These improvements were most pronounced

at 3 months and remained evident at 6 months; nearly half of patients maintained at least 50% pain relief. Importantly, the procedure was associated with a favorable safety profile and lacked serious adverse events or permanent neurological complications. These findings support the potential clinical utility of cryoneurolysis as a safe and minimally invasive interventional option for carefully selected patients with SIJ pain refractory to conservative treatment [13].

The magnitude and durability of analgesic improvement observed in this cohort are consistent with the established neurophysiological effects of cryoneurolysis. Cryogenic application induces axonotmesis via disruption of axonal and myelin integrity while preserving the surrounding connective tissue framework, including the endoneurium and perineurium [16]. This structural preservation allows controlled interruption of nociceptive signal transmission while maintaining the potential for subsequent axonal regeneration. Unlike thermal neuroablation, which induces coagulative necrosis and irreversible tissue injury, cryoneurolysis produces a reversible lesion that limits the risk of permanent nerve damage and neuroma formation [11,12]. The sustained yet gradually attenuating analgesic effect observed during follow-up is consistent with progressive axonal regeneration and restoration of neural conduction, which typically occur over several months. This mechanism may also explain the modest increase in NSAID use observed between 3 and 6 months after the procedure. The partial rebound in analgesic use paralleled the increase in NRS scores during the same interval and is consistent with gradual restoration of nociceptive transmission secondary to axonal regeneration following cryogenic axonotmesis.

The responder rates observed in this cohort are comparable to those reported for radiofrequency ablation of the sacral lateral branches, which remains the most commonly used neuroablative technique for SIJ pain. Previous randomized and observational studies have shown responder rates ranging from approximately 40% to 70%, depending on patient selection, procedural technique, and lesion characteristics. Responder rates observed in the present study fall within this range, suggesting comparable clinical effectiveness [17,18]. However, cryoneurolysis may offer distinct technical advantages. The circumferential cryogenic lesion generated by the expanding ice ball may provide more comprehensive coverage of anatomically variable lateral branch nerves than the relatively focal lesions produced by conventional radiofrequency ablation [19,20]. Given the well-documented variability in sacral lateral branch anatomy, incomplete nerve capture represents a major limitation of thermal denervation [21]. The ability of cryoneurolysis to create larger, more homogeneous lesions may increase the likelihood of successful denervation and could partially explain the favorable clinical outcomes observed in the present cohort [22].

In addition to reducing pain intensity, cryoneurolysis was associated with substantial and clinically meaningful improvement in functional disability. Improvements in ODI scores indicate that treatment benefits extended beyond symptom reduction and translated into enhanced physical function and performance of daily activities. Functional recovery represents a critical therapeutic objective in the management of chronic low back pain, given that disability and functional limitation are primary determinants of quality of life and socioeconomic burden [23,24]. The observed reduction in analgesic consumption, including discontinuation of opioid-containing medications in a substantial proportion of patients, further supports the practical significance of these findings. Opioid exposure reduction is particularly important considering the well-established risks of opioid dependence, tolerance, and systemic adverse effects associated with long-term opioid therapy [25].

The favorable safety profile observed in this study further supports the clinical utility of cryoneurolysis. No serious complications, infections, or permanent neurological deficits were observed; all reported adverse events were mild and transient. This safety profile is consistent with the known biological effects of cryogenic nerve injury, which preserves connective tissue architecture and reduces the risks of neuroma formation and irreversible nerve damage [13,26]. Additionally, the absence of corticosteroid use eliminates potential steroid-related adverse effects, including metabolic disturbances, immunosuppression, and tissue degeneration. These characteristics make cryoneurolysis an attractive alternative for patients in whom corticosteroid administration is contraindicated or undesirable [19,27].

Careful patient selection and procedural technique likely were substantial contributing factors for the observed treatment success. All patients included in this study demonstrated a positive response to a diagnostic SIJ block, which is widely recognized as a critical predictor of successful neuroablative outcomes. Diagnostic confirmation improves identification of the SIJ as the predominant pain generator and reduces the risk of treating non-sacroiliac sources of pain. Furthermore, the multilevel targeting strategy utilized in the present study, involving lateral branches from L5 through S3, presumably improved denervation completeness. Given the complex and variable innervation of the SIJ, comprehensive targeting of multiple segmental levels is essential to achieve consistent and durable analgesic outcomes.

The multicenter design and relatively large cohort strengthen the external validity and generalizability of the present findings. The inclusion of consecutive patients treated in real-world clinical settings reflects routine clinical practice and enhances the applicability of the results. Although cryoneurolysis has been widely used in the management of various neuropathic and musculoskeletal pain conditions, clinical evidence

specifically addressing SIJ-mediated pain remains limited. The present study contributes important clinical data supporting its potential utility for this indication and expands the range of minimally invasive treatment options available for such a challenging condition.

Several limitations should be considered when interpreting these findings. First, the retrospective observational design without a control group limits the ability to directly compare cryoneurolysis with alternative treatments, such as radiofrequency ablation or intra-articular corticosteroid injection; it may introduce risks of selection bias, incomplete data capture, and unmeasured confounding. Second, although the cohort was relatively large, randomized controlled trials are needed to confirm these findings and establish comparative effectiveness. Third, the follow-up period was limited to 6 months, and longer-term studies are needed to evaluate the durability of analgesic benefit and the effects of nerve regeneration over time.

An additional limitation of this study relates to the diagnostic confirmation strategy used for patient selection. SIJ-mediated pain was confirmed using a single fluoroscopy-guided intra-articular diagnostic block rather than dual comparative blocks with different local anesthetics, which are considered the reference standard in some interventional pain management guidelines. The use of a single diagnostic block may increase the risk of false-positive responses and could potentially result in the inclusion of patients without true SIJ-mediated pain, thus leading to partial overestimation of treatment-associated outcomes. However, the use of a single diagnostic block reflects common real-world clinical practice in many interventional pain centers and was consistently applied across all participating institutions.

Finally, outcome measures were based primarily on patient-reported pain and disability scores, which, although clinically relevant and widely accepted, can be influenced by subjective factors.

Future research should focus on randomized controlled trials comparing cryoneurolysis with established interventional techniques, particularly radiofrequency ablation, to better define relative effectiveness and optimal patient selection criteria. Additional investigation of procedural parameters, including lesion number, probe placement strategies, and predictors of treatment response, may further optimize patient outcomes. Long-term studies evaluating repeat cryoneurolysis and the durability of analgesia will also be important for clarifying its role within chronic pain management algorithms.

Conclusions

This multicenter observational study demonstrated that cryoneurolysis of the sacral lateral branches is a safe and effective minimally invasive treatment for chronic SIJ-mediated pain. The procedure was associated with substantial and clinically meaningful reductions in pain intensity, improved functional outcomes, and reduced reliance on analgesic medications while maintaining a favorable safety profile. These findings support cryoneurolysis as a valuable interventional option for appropriately selected patients with SIJ pain, particularly those with conservative treatment failure or for whom alternative neuroablative techniques are unsuitable.

Institutions Where Work Was Done

Neurolocus Pain Management Centre, Warsaw, Poland and Pain Treatment Clinic, Our Lady of Perpetual Help Hospital in Wołomin, Wołomin, Poland.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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