

Clinical observation of CT-guided intra-articular conventional radiofrequency and pulsed radiofrequency in the treatment of chronic sacroiliac joint pain

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Background: Sacroiliac joint pain (SIJP) is an important cause of low back pain and seriously affects the patients' quality of life. Therefore, it is urgent to find effective treatment methods.

Objective: To observe the efficacy of intra-articular (IA) conventional radiofrequency (CRF) and pulsed radiofrequency (PRF) treatment of Sacroiliac joint syndrome (SIJS) under computed tomography (CT) guidance.

Study design: Retrospective comparative study.

Setting: Shengjing Hospital of China Medical University.

Patients and methods: Sixty-four patients with SIJS were enrolled in the Pain management. Patients were randomized into two groups: CRF (CRF group, n=32) and PRF (PRF group, n=32). At each observation time, the general condition, visual analog scale (VAS), the total efficiency rate, Oswestry disability index (ODI), and 36-item short-form health survey were followed up.

Results: Compared to the pretreatment value, the VAS and the ODI decreased in both groups after treatment ($P<0.05$). In the CRF group, the VAS and the ODI decreased significantly at 1 week after treatment ($P<0.05$); at 6 and 12 months after treatment, the VAS and the ODI were lower than that in the PRF group ($P<0.05$). The total efficiency rate in the CRF group and PRF group was 56.3% and 31.3%, respectively ($P<0.05$). After the relief of pain, both groups received different degrees of improvement in the quality of life. Compared to the pretreatment value, physical component summary (PCS) and the mental component summary (MCS) in both groups were increased after treatment ($P<0.05$); in the CRF group, PCS and MCS increased significantly at 1 week after treatment ($P<0.05$); and at 6 and 12 months after treatment, PCS and MCS were higher than those in the PRF group ($P<0.05$).

Conclusion: CT-guided IA PRF and CRF in the treatment of sacroiliac pain are safe and effective. CRF is superior to PRF in the early and late stage. It is recommended for the treatment of SIJP.

Keywords: sacroiliac joint pain, conventional radiofrequency, pulsed radiofrequency, intra-articular, sacroiliac joint syndrome

Introduction

Sacroiliac joint pain (SIJP) is an important cause of low back pain. Acute or chronic injury to sacroiliac joint (SIJ) cartilage, joint capsule, peripheral ligament, and soft tissue occurs in SIJP followed by pain in the lumbosacral and lower extremities.^{1,2} At present, 15%–30% of low back pain is caused by SIJ disease.³ This seriously affects the patients' quality of life and is also the main cause of early incapacity. There are many diseases causing SIJS, the pathogenesis is unclear, and the diagnosis is difficult.⁴

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The course of SIJS tends to be long and difficult to cure. Therefore, it is urgent to find effective treatment methods.

SIJ block is a traditional treatment method. It can effectively relieve the SIJP, but the maintenance time is short, the long-term treatment effect is limited, and repeated treatment is needed.⁵ Radiofrequency treatment can alleviate neuropathic pain, knee pain, and so on^{6,7} and has gradually become a common technique for treating chronic pain. Radiofrequency includes conventional radiofrequency (CRF) and pulsed radiofrequency (PRF). Radiofrequency is minimally invasive. Testing before treatment can be accurately positioned, with the advantages of safety and repeatability. Therefore, it is widely used. The temperature range of CRF is 75–95°C. The higher the temperature, the more serious damage to the nerve, and the higher the complications such as numbness.⁸ This also limits the scope of its application. The temperature of the PRF does not exceed 42°C and there is almost no damage to the nerve. PRF analgesic effect is independent of temperature but is related to neuromodulation. However, the effect is slow and the recurrence rate is high.^{9,10}

There have been many reports on the treatment of SIJS by radiofrequency denervation (RFD), but RFD requires precise and careful selection of nerves. Intra-articular radiofrequency (IARF) treatment is safer than RFD, but there are few studies on IARF in the treatment of SIJP. This study was to observe the efficacy of intra-articular (IA) CRF and PRF treatment of

SIJS under computed tomography (CT) guidance. Oswestry disability index (ODI), the total efficiency rate, and quality-of-life improvement (36-item short-form health survey [SF-36]) were compared and observed for clinical outcome.

Methods

Patients

From January 2015 to December 2016, 64 patients with SIJS were enrolled in the Pain management, Shengjing Hospital of China Medical University. Patients were randomized into two groups according to the order of entry: CRF (CRF group, n=32) and PRF (PRF group, n=32) (Figure 1). The study was approved by the Ethics Committee of Shengjing Hospital of China Medical University. All patients were informed of risks and complications before treatment, and the written informed consent was obtained from all patients.

Inclusion criteria: conforming to IASP's definition of SIJP.¹¹ 1) the course of disease was more than 1 month; 2) pain in one or bilateral lumbosacral regions, severe patients with pain in the hips, groin, and lower extremities; 3) moderate to severe pain, the visual analog scale (VAS) of 24 hours average pain intensity scores was >5 points before enrollment; 4) physical examination: tenderness and percussion pain in the sacroiliac region, a positive result in at least one of the following tests (Patrick sign, compression and distraction test, Gaenslen sign), and no abnormalities in neurologic examination; 5) CT or magnetic resonance examination suggested

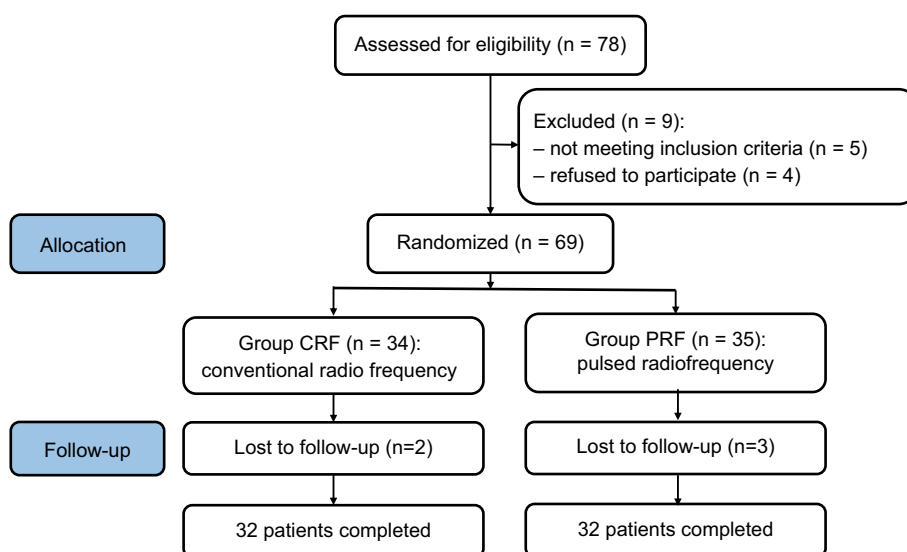


Figure 1 Schematic illustration of the study design.

Note: All 64 patients were included in the treatment.

Abbreviations: CRF, conventional radiofrequency; PRF, pulsed radiofrequency.

sacroiliac arthritis; 6) IA block could relieve more than 50% pain; and 7) conservative treatment was ineffective.

Exclusion criteria: 1) tumor, tuberculosis, postoperative SIJ pain, and other secondary SIJ lesions; 2) local puncture area infection; 3) patients with mental illness, mental retardation, and disturbance of consciousness; 4) severe liver, kidney, and cardiopulmonary diseases; 5) patients with abnormal coagulation function; and 6) patients with local anesthetic drug allergy.

Treatment method

The venous access was established, and ceftriaxone sodium was given to prevent infection at 30 minutes before treatment.

Under CT guidance, the patient was placed in a prone position and vital signs were monitored during the treatment. After local disinfection, 0.5% lidocaine was used for layer-by-layer infiltration anesthesia. The radiofrequency needle was taken along the established puncture angle and path to the IA SIJ. CT scan was confirmed again to further adjust the needle directly to the IA SIJ. The RF needle was further connected to the RF instrument for testing: 50 Hz, 0.1–0.3 V test sensation and 2 Hz, 0.1 V test exercise, no induction of hips and lower extremity muscle tremors and pain. The treatment was started after the position was satisfactory. 1) CRF group: started at 50°C and gradually heated up to the target temperature of 80°C for 180 seconds. 2) PRF group: 42°C PRF 600 seconds. After CRF or PRF treatment, both groups were injected with an analgesic complex solution (2% lidocaine 1.5 mL + compound betamethasone 5 mg + normal saline 0.5 mL) 3 mL. The needle was removed and the puncture point was pressed. The patient was observed for 15 minutes and then returned to the ward.

Observations and follow-up

General condition was recorded before treatment, including age, gender, pain duration, VAS, pain position, and pain side. Follow-up evaluations were performed at 1 week, 2 weeks, 1 month, 3 months, 6 months, and 12 months, respectively. Evaluations were followed up by medical staffs of the non-surgical group using a double-blind approach.

1. VAS pain score: 0 points (painless) to 10 points (intolerable pain).
2. The total efficiency rate: according to the WHO assessment criteria for pain relief, the efficacy was divided into four levels. Subjective symptoms and clinical signs were assessed at 12 months, divided into complete remission (CR), partial remission (PR), mild remission (MR), and no remission (NR). CR: pain disappeared; PR: pain was

significantly relieved; MR: pain was relieved; and NR: pain was not relieved, and sometimes autonomic dysfunction suffered. The total efficiency rate (%) = $[(CR + PR + MR)/n] \times 100\%$.

3. ODI: assessed the disability and pain levels. ODI consisted of two questions, including pain intensity, self-care, lifting, walking, sitting, standing, interfering with sleep, sexual life, social life, and tourism. Each question had six options and was scored as 0–5 options. The sum of scores was expressed as a percentage: 0% represented no pain or disability, while 100% represented the most severe pain and disability.
4. SF-36 assessment¹²: assessed the quality of life before and after treatment, including physical and mental status. The physical state included physical function, physical role, bodily pain, and general health; mental state included vitality, social function, emotional role, and mental health. Finally, the physical component summary (PCS) and the mental component summary (MCS) were calculated.

Statistics

SPSS18.0 statistical software (IBM Corporation, Armonk, NY, USA) was used to analyze the data. The single-sample Kolmogorov–Smirnov test was used to test the normality of the measurement data. The normal distribution variables were compared using one-way ANOVA followed by least significant difference pairwise comparison; values were expressed as the mean \pm SD ($\bar{x} \pm SD$). The abnormal distribution variables were compared using the Kruskal–Wallis rank sum test; values were expressed as the median \pm IQR. Chi-square test or Fisher's exact test was used to analyze the enumeration data. $P < 0.05$ was statistically significant.

Results

General condition before treatment

There was no significant difference in the general condition between two groups before treatment, including age, gender, pain duration, VAS, and pain position and side ($P > 0.05$) (Table 1).

Intratreatment patient condition

All patients completed the treatment. Under the guidance of CT, the needle was inserted at a specific angle and depth. The CT scan showed that the tip of the needle was located in the IA SIJ. The three-dimensional CT could further clarify the position, showing that the RF needle was located at the SIJ. Tremors and painful sensations in the hips and lower extremity muscles were not induced by the sensory and exercise

tests. Patients in both groups had no serious complications such as spinal cord injury and limb weakness after treatment (Figure 2).

VAS before and after treatment

At each observation point, the VAS in both groups decreased after treatment. Compared to pretreatment value, the difference was significant ($P<0.05$). CRF group had a rapid onset, and VAS decreased significantly at 1 week after treatment. Compared to the PRF group, the difference was statistically significant ($P<0.05$); the PRF group had a slow onset, and VAS decreased gradually. At 2 weeks, and 1 and 3 months, there was no significant difference between the two groups ($P>0.05$). The pain relief in the CRF group was maintained for a long time. At 6 and 12 months after treatment, the VAS

was lower than that in the PRF group, and the difference was significant ($P<0.05$) (Figure 3).

The total efficiency rate

The total efficiency rate in the CRF group and PRF group was 56.3% and 31.3%, respectively. The difference between the two groups was significant ($P<0.05$) (Table 2).

ODI before and after treatment

At each observation point, the quality of life in both groups improved and the ODI decreased after treatment. Compared to the pretreatment value, the difference was significant ($P<0.05$). The CRF group improved quickly, and ODI decreased significantly at 1 week after treatment. Compared to the PRF group, the difference was significant ($P<0.05$).

Table 1 General condition before treatment

Parameters	Group	
	CRF	PRF
Patients (n)	32	32
Gender (n, %)		
Female	13 (40.6)	11 (34.4)
Male	19 (59.4)	21 (65.6)
Age (years, range)	49.68±5.23 (42–56)	50.45±5.45 (43–57)
Pain duration before treatment (months, range)	15.67±3.19 (10–21)	15.92±3.53 (11–20)
VAS before treatment	7.05±1.25	7.12±1.17
Side (n, %)		
Right	11 (34.4)	9 (28.1)
Left	9 (28.1)	12 (37.5)
Both	12 (37.5)	11 (34.4)
Pain position		
Hips	32 (100)	32 (100)
Groin	10 (31.3)	8 (25.0)
Lower extremities	7 (21.9)	8 (25.0)

Note: Data are presented as numbers (n, %) of patients or mean±SD.

Abbreviations: CRF, conventional radiofrequency; PRF, pulsed radiofrequency; VAS, visual analog scale.

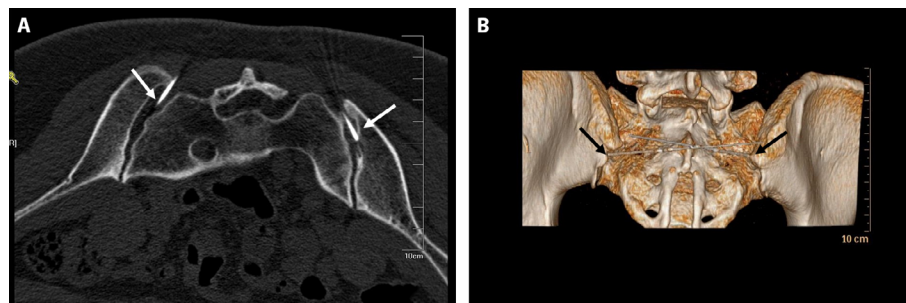


Figure 2 (A) CT scan showed that the tip of the needle was located in the intra-articular sacroiliac joint, as indicated by the white arrows; (B) three-dimensional CT reconstruction showed that the radiofrequency needle was located at the sacroiliac joint, as indicated by the black arrows.

Abbreviation: CT, computed tomography.

The quality of life in the PRF group improved slowly and the ODI decreased gradually. At 2 weeks, and 1 and 3 months, there was no significant difference between the two groups ($P>0.05$). The quality of life improvement in the CRF group was maintained for a long time. At 6 and 12 months after treatment, the ODI was lower than that in the PRF group, and the difference was significant ($P<0.05$) (Table 3).

SF-36 before and after treatment

After the relief of pain, both groups received different degrees of improvement in the quality of life, including physical function, physical role, bodily pain, general health, vitality, social function, emotional role, and mental health. At each observation time point, PCS and MCS in both groups were

increased after treatment. Compared with the pretreatment value, the difference was significant ($P<0.05$); PCS and MCS in both groups increased gradually. The increase was most obvious at 3 months and decreased at 6 and 12 months. The CRF group improved quickly, and PCS and MCS increased significantly at 1 week after treatment. Compared to the PRF group, the difference was significant ($P<0.05$). The improvement of the PRF group was relatively slow. At 2 weeks, and 1 and 3 months, there was no significant difference between the two groups ($P>0.05$). In the CRF group, the improvement of the quality of life was maintained for a long time. At 6 and 12 months after treatment, PCS and MCS were higher than those in the PRF group, and the difference was significant ($P<0.05$) (Figure 4).

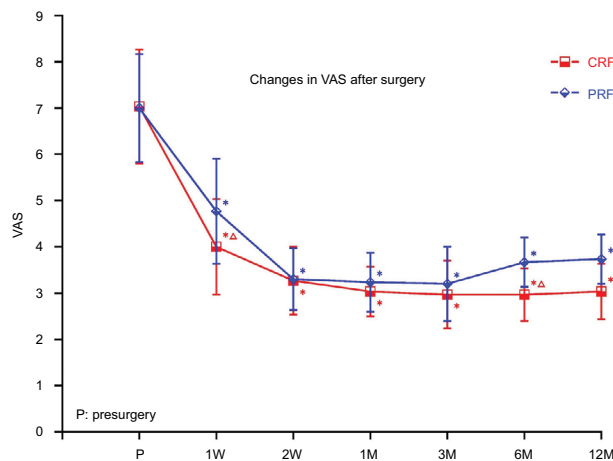


Figure 3 The comparison of VAS in two groups (mean ± SD). **Notes:** Data are presented as mean±SD. Compared to pretreatment value, * $P<0.05$; CRF group compared with the PRF group, $\Delta P<0.05$. **Abbreviations:** CRF, conventional radiofrequency; M, months; PRF, pulsed radiofrequency; W, weeks.

Discussion

SIJP is difficult to distinguish from other sources of low back pain through medical history and physical examination. The innervation is complicated, so the problem of SIJ is easily overlooked.^{1,13} The incidence of SIJP caused by various reasons is increasing, and the treatment of SIJP poses a huge challenge and requires extensive attention.

The SIJ has a deep position and special shape, with unique characteristics.² Early sacroiliac arthritis occurs in the synovial membrane, and the iliac side is more important than the sacrum side.¹⁴ Therefore, the puncture target should choose the synovial part, and the needle should also face the iliac side. Anatomically, the individual differences in distance between the posterior edge and the midline and the angle of the SIJ are large. Therefore, accurate positioning is very difficult. The X-ray fluoroscopy cannot guide the puncture needle into the SIJ due to its overlapping structure and low-density resolution; while the density resolution and the spatial

Table 2 Comparison of the total efficiency rates after treatment in two groups

	n	CR	PR	MR	NR	Total efficiency (%)
CRF	32	6 (18.8%)	7 (21.9%)	5 (15.6%)	14 (43.7%)	18 (56.3%)
PRF	32	3 (9.4%)	5 (15.6%)	2 (6.3%)	22 (68.7%)	10 (31.3%)

Note: Compared to the PRF group, * $P<0.05$. **Abbreviations:** CR, complete remission; CRF, conventional radiofrequency; MR, mild remission; NR, no remission; PR, partial remission; PRF, pulsed radiofrequency.

Table 3 Comparison of ODI in two groups

Group	Before treatment	After treatment					
		1 week	2 weeks	1 month	3 months	6 months	12 months
CRF	48.67±11.02	35.94±7.64* Δ	32.52±6.23*	32.14±6.10*	28.76±5.78*	28.93±4.78* Δ	29.97±5.32* Δ
PRF	48.92±10.42	41.36±8.51*	32.91±6.47*	32.25±5.97*	30.84±6.23*	33.67±5.54*	34.98±6.48*

Notes: Data are presented as mean±SD (%). Compared to the pretreatment value, * $P<0.05$; CRF group compared to the PRF group, $\Delta P<0.05$. **Abbreviations:** CRF, conventional radiofrequency; ODI, Oswestry disability index; PRF, pulsed radiofrequency.

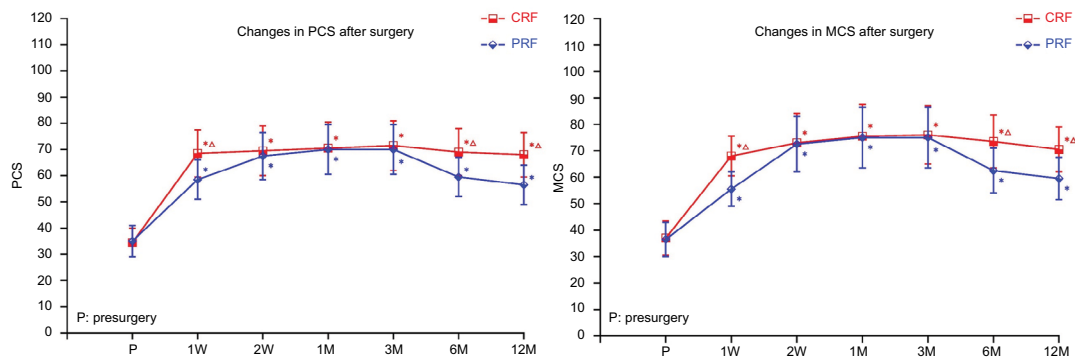


Figure 4 The comparison of 36-item short-form health survey before and after treatment in two groups.

Notes: Results are presented as mean \pm SEM. Compared to the pretreatment value, * $P < 0.05$; CRF group compared to the PRF group, $\Delta P < 0.05$.

Abbreviations: CRF, conventional radiofrequency; MCS, mental component summary; PCS, physical component summary; PRF, pulsed radiofrequency.

resolution in the plane of the CT are high, there is no overlapping interference. It is an effective positioning and guiding method for the SIJ synovial puncture. Positioning under CT guidance, the angle and depth can be clearly defined, and the SIJ synovial membrane can be directly penetrated through the ligament. In this study, all patients completed the treatment successfully. In the CT scan image, it was observed that RF needle tip was located at the junction of the middle 1/3 and the lower 1/3 of the SIJ, where all or most of the SIJ was the synovial membrane¹⁵ and the direction was relatively straight and suitable for puncture; three-dimensional CT could further clarify the position and showed that the RF needle was located at the SIJ. During the puncture, it was necessary to avoid puncturing the pelvic cavity and damaging the pelvic structure (the posterior wall of the pelvis, the internal iliac vessel, and the lumbosacral trunk near the lower 1/3 of the SIJ). The puncture RF needle was tilted slightly to the iliac side to reduce the chance of penetrating into the pelvic cavity. Before the radiofrequency treatment, the sensory and exercise tests were further performed. No hips and the lower extremity muscles were induced to tremble and no pain was induced, then the radiofrequency treatment was performed. After treatment, patients experienced minor complications such as local swelling, pain at the needle puncture site, dizziness, flushing, sweating, nausea, and hypotension, but those were short-lived and self-limiting. In this study, no serious complications such as spinal cord injury and limb weakness occurred.

At present, there are various treatment options for sacroiliac pain, including conservative treatment, interventional therapy, and surgical treatment. The treatment is selected according to the patient's condition, and conservative treatment is preferred. Most patients may have a better curative

effect. However, some patients have poor conservative treatment effect and the course of the disease is prolonged. At this time, interventional therapy can be further considered. Interventional therapy has the advantages of small trauma, quick recovery, short operation time, and short postoperative hospital stay, while the surgical treatment is often the last choice because of the large trauma. IA injection of local anesthetics and cortisol directly into the joints can quickly decrease inflammation in and around the joints, relieve pain, and promote tissue repair, but the maintenance time is short and repeated treatment always has more side effects.⁵ RFD is one of the most rapidly developing technology in recent years. In some intractable sacroiliac pain, some scholars had achieved good results by using radiofrequency thermo-coagulation. Studies had shown that RFD was effective in treating chronic refractory SIJP. The effective rate of 6 months after treatment could reach 49.9%,¹⁶ and in some studies, the effective rate of 9 months after RFD reached 89%¹⁷ and could provide significant relief for up to one year.³ Gevargez et al¹⁸ applied CRF to the posterior interosseous sacroiliac ligaments and the dorsal rami of the L5 spinal nerve. No pain was reported by 34.2%, and significant pain relief was experienced by 31.6%. Cohen et al¹⁹ retrospectively evaluated 40 patients in two institutions. The patients received RFD of L4–L5 primary dorsal rami and S1–S3 lateral branches. Fifty-two percent obtained positive results and believed that the CRF was effective in the treatment of sacroiliac pain, and the long-term effect was satisfactory.³ However, van Tilburg CW et al²⁰ performed radiofrequency on the S1–S4 nerve root lateral branches and L5 posterior branch. Compared with the sham group, the hypothesis of no difference in the pain reduction or global perceptual effect cannot be rejected. CRF could cause nerve damage, which easily led to local sensory

retardation, sensory degeneration, abnormal pain, persistent weakness in the lower limbs, and other complications such as burning and numbness. As the maximum temperature of the PRF electrode does not exceed 42°C, there is no significant nerve damage in the PRF compared to the CRF. Ahadian²¹ found that PRF was similar to CRF on demonstrating response rates for facet arthropathy, sacroiliac arthropathy, and many other chronic pain conditions. Vallejo et al²² performed pulsed RFD on the lateral branch of the medial branch of L4, posterior primary rami of L5, and lateral branches S1–S2. A “good” (VAS decrease >50%) or “excellent” (VAS decrease >80%) pain relief was experienced by 72.7%, the long-term effect was satisfactory, and it was effective for the treatment of intractable SIJ dysfunction. At present, there are many studies on radiofrequency treatment of local ligament and denervation, but few studies on IA SIJ radiofrequency. Schianchi et al performed IA PRF on the shoulder, knee, trapezio-metacarpal, and first metatarsophalangeal joints, and the pain in most of the joints was significantly alleviated.²³ Studies had shown that PRF was superior to CRF in small joint-derived pain.^{24,25} The use of IA PRF in advanced knee osteoarthritis was also effective and safe,²⁶ but the efficacy on the large joint of the SIJ was still unclear.

In this study, IA CRF and PRF were used to treat sacroiliac pain. It was found that in both groups, the VAS and ODI decreased, and PCS and MCS increased. Compared to the pretreatment value, the difference was significant in both groups ($P<0.05$), indicating that both treatments were effective and could alleviate the symptoms of SIJP. The analgesia effect in the CRF group was rapid and the quality of life improved in the early stage. The VAS decreased significantly and the quality of life improved 1 week after treatment. The pain relief and quality-of-life improvement could sustain for a long time, up to 6 months and 12 months after treatment, and the difference was significant between the two groups ($P<0.05$). In the PRF group, the effect was slow, and VAS and ODI decreased gradually. The same analgesic effect as CRF was achieved at 2 weeks, and 1 and 3 months, but the maintenance time was short. CRF is a neurodestructive technique. The high-frequency current causes the ions in the tissue to oscillate, causing local heating. The A δ and C-type nerve fiber that transmits pain are coagulated and denatured by heating. As the conductive tactile nerve fibers (A α and A β) can tolerate relatively high temperatures, they are not damaged. CRF blocks the action potential by cutting off the sensory pathway and then the pain relieves.^{27,28} While PRF does not damage the nerve, pain relief may be related to reversible neurons temporar-

ily blocking nerve signals through the nerve conduction pathway. PRF could inhibit MAPK activation, reduced cytokine release, and inhibited the excitatory amino acids release in the spinal cord.²⁹ Moreover, PRF could attenuate JNK activation in spinal dorsal horn,³⁰ inhibited spinal cord sensitization, and regulated the expression of multiple genes in the pathway. The expressions of anti-inflammatory factor genes (GABAB-R1, Na/K-ATPase, and 5-HT3r) were enhanced, while the expressions of proinflammatory factor genes (TNF- α and IL-6) were decreased,³¹ so the pain was relieved.³² Therefore, the analgesic effect of PRF was slow and its long-term analgesic effect might be related to neuromodulation. The total efficiency rate in the CRF and PRF groups was 56.3% and 31.3% at 12 months after treatment. The difference between the two groups was significant ($P<0.05$). The action point of this study was located in IA SIJ, which caused no nerve damage and can be safely treated with CRF. The IA SIJ radiofrequency is different from RFD. Nerves are segmental distribution requiring multiple segments for ablation, while the volume of the SIJ is very limited, and the surrounding bone also has an insulating property. In the joint, part of the current is deflected by the bone surface, retaining the current intensity and electric field in the joint space and not being diluted rapidly at long distances. Therefore, the current intensity and electric field in IA SIJ will be higher than that of the electrode in the soft tissue, so it has a superior analgesic effect.³³ Thus, we chose only one location for radiofrequency ablation. However, the position of the RF needle was required to be accurate, that was why we chose CT-guided one.

This study had several limitations. The study was a retrospective study, and it was already known that the efficacy of simple SIJ block injections was short, so we did not set up a control group for the patient's treatment effect. Patients with postoperative SIJ pain were not included in our inclusion criteria, so the indications for the use of radiofrequency were relatively inadequate. At the same time, mechanisms of the RF should be further studied, such as cytokines.

In summary, CT-guided IA PRF and CRF in the treatment of sacroiliac pain is safe and effective. It could significantly alleviate sacroiliac pain, reduce ODI, and improve the quality of life physically and mentally. CRF is superior to PRF in the early and late stages. It is recommended for the treatment of SIJP.

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Disclosure

The authors report no conflicts of interest in this work.

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