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Letter to the Editor

INTERVENTIONAL TREATMENT OF SACROILIAC JOINT DISEASE

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ABSTRACT

Sacroiliac joint (SIJ) disease is a common cause of lower back and buttock pain. It poses a significant diagnostic and therapeutic challenge due to its complex anatomy and varied clinical presentation. Interventional treatments have emerged as effective options for managing SIJ disease, offering potential pain relief and improved quality of life for patients. This comprehensive review explores the interventional treatment modalities available for sacroiliac joint disease, including diagnostic techniques, minimally invasive procedures, and emerging therapies. We delve into the evidence-based literature, discuss the efficacy and safety profiles of these interventions, and highlight key considerations for their implementation. By examining the interventional armamentarium for SIJ disease, this review aims to provide clinicians and patients with a thorough understanding of the available options and inform decision-making in the management of this challenging condition.

KEYWORDS: *sacroiliac joint, fixation, injection*

INTRODUCTION

The sacroiliac joint (SIJ) plays a crucial role in load transfer and stability of the pelvis, linking the spine to the lower

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extremities; while the SIJ disease refers to a range of pathologies including inflammation, degeneration, and instability the SI pain refers to discomfort or pain in the sacroiliac joint (1). SI pain can manifest as pain, tenderness, or discomfort in the lower back, buttocks, hips, or groin area that may be exacerbated by sitting, standing, walking, or climbing stairs (2).

The pain may be localized to one side or can radiate down the leg, resembling sciatica leading to difficulties in differential diagnosis (1-2). The exact prevalence of SI joint-related LBP is challenging to determine due to diagnostic difficulties and varying definitions of SI joint dysfunction. However, studies suggest that the SI joint is a potential source of LBP in approximately 15% to 30% of individuals with chronic low back pain without significant gender difference (3-4).

Despite its prevalence, diagnosis and treatment of SIJ disease remain challenging due to its complex anatomy and the lack of specific clinical and radiographic findings. The advent of interventional techniques has revolutionized the management of SIJ disease, providing targeted therapies and enhancing patient outcomes.

Diagnosis of sacroiliac pain

Diagnosing sacroiliac (SI) pain can be challenging because the symptoms may overlap with other conditions affecting the lower back and hips. The diagnosis of sacroiliac (SI) pain typically involves a comprehensive evaluation that includes a combination of medical history, physical examination including and diagnostic tests; once the diagnosis is confirmed, long-term solutions may be considered.

1. Medical History: several factors can increase the risk of developing SI pain, including:

- pregnancy and childbirth: The hormonal changes and increased stress on the SI joints during pregnancy can contribute to SI pain. It is estimated that up to 60% of pregnant women may experience SI joint pain (5);
- trauma or injury: accidents, falls, or repetitive activities that strain the SI joint can lead to SI pain (2). SIJ disease is present in 45%-75% patients undergone posterior fixation treatments (fig. 1a, b);

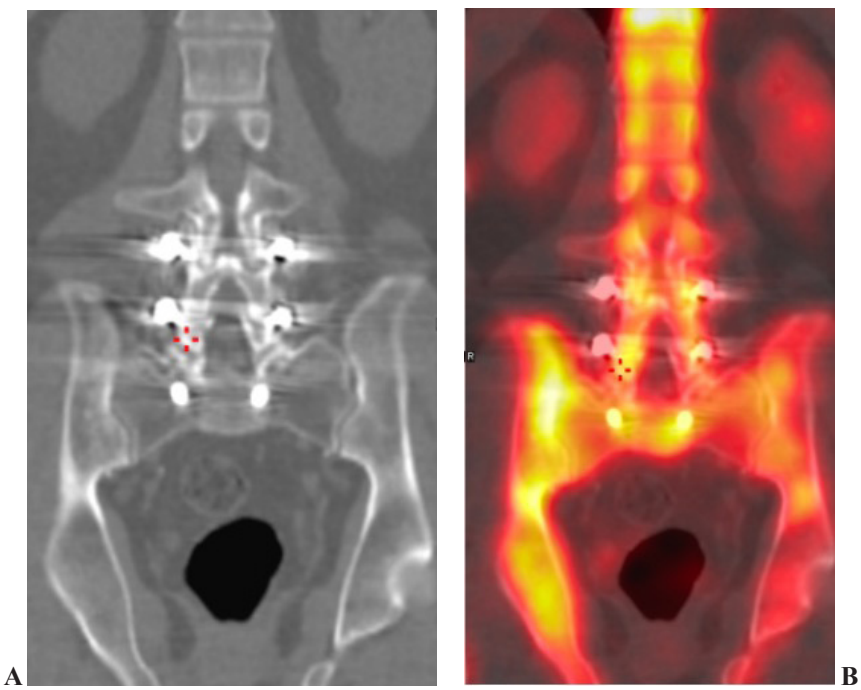
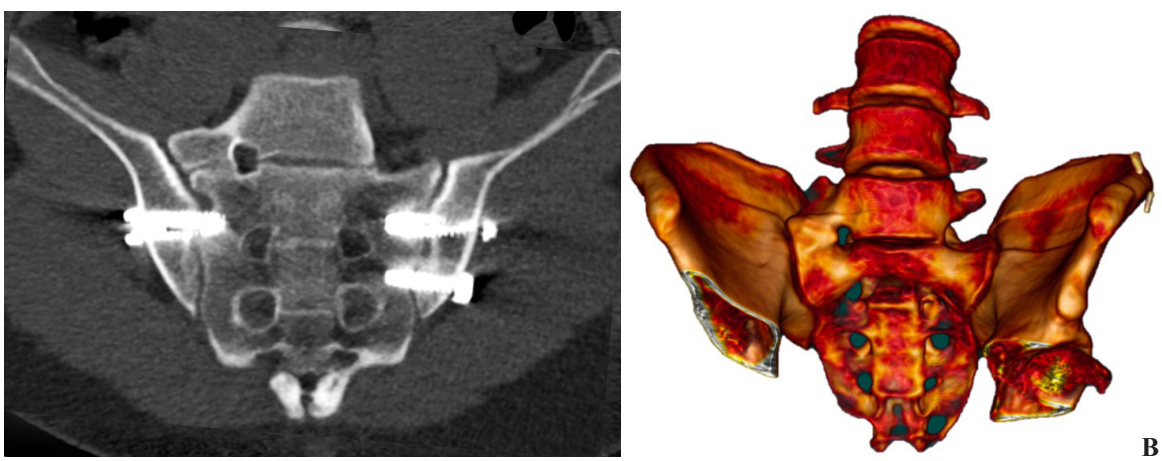


Fig. 1. *Chronic right-side pain and sacro-ileitis in a patient undergone posterior fixation. Coronal CT 2D recon demonstrates transpeduncolare screws at the level of L4, L5 and S1, in a patient treated 5 years before with surgical posterior fixation. No significant bone abnormality can be detected on CT scan (**1a**). On SPECT-CT scan, evident Tc99 uptake can be detected at the level of right SIJ area as well as right iliac bone, secondary to posterior fixation (**1b**).*

- inflammatory conditions: certain inflammatory diseases, such as ankylosing spondylitis and psoriatic arthritis, can affect the SI joints and lead to pain (6);
- degenerative conditions: conditions like osteoarthritis or degenerative joint disease can affect the SI joints and cause pain (7). Transitional lumbar vertebra is another condition commonly associated to the SIJ disease (Fig. 2a, b).

2. Physical examination: clinical evaluation involves (2):
- posture assessment;
- range of motion in order to assess the mobility and stability of the SI joint using maneuvers such as the FABER (flexion, abduction, external rotation) test, Gaenslen's test, and the thigh thrust test aid in identifying SIJ pathology;
- provocative tests able to reproduce SI joint pain stressing the SI joint in various positions to determine if it is the source of pain.

3. Imaging tests: no specific radiological findings for the diagnosis of sacroiliac joint-related pain however diagnostic imaging tests are often used to help confirm the diagnosis and rule out other possible causes of pain.
These may include:
- plain films: X-rays can provide a basic view of the SI joint and can help identify fractures, degenerative changes, or abnormalities in the joint structure;
- It is important to remember that the SI joint has a complex three-dimensional structure, and plain film X-rays provide a two-dimensional representation. This limitation can make it challenging to accurately assess the joint's full extent, especially regarding subtle changes or early-stage pathology. Neverless, radiographic features such as erosions, sclerosis, and ankylosis are typically seen in advanced inflammatory sacroiliitis and are graded from 0 (normal) to 4 (ankylosis) according to the modified New York criteria (8).
- Magnetic Resonance Imaging (MRI): an MRI scan can provide more detailed images of the SI joint, soft tissues, and surrounding structures. It can help detect inflammation, joint abnormalities, or other potential causes of pain and it has been introduced for the evaluation of axial spondylarthritis due to contrast resolution and 3D according to sacrum plane (9).
- Computed Tomography (CT) scan: a CT scan may be ordered to provide a detailed, cross-sectional view of the SI joint and surrounding structures, particularly if there is a suspected bony abnormality.



A **B**

Fig. 2. *Right L5 emisacralization in a patient with transitional vertebra and bilateral sacroiliac pain. On 3D CT recons there's evident fusion between the right L5 hemivertebra and the ipsilateral sacral wing, concurring to the asymmetrical loadstress and SIJ disease development (**2a**). Bilateral SIJ fixation putting 2 screws on regular left side, one at the S1 level and the second at S2, and a third contralateral screw at S1 level were introduced, resolving the clinical symptoms related to the disease (**2b**).*

- CT Sensitivity, accuracy and detailed information compared to plain radiography. However, due to higher radiation exposure, it is not advisable to use CT for diagnosis or follow-up purposes.
- nuclear medicine is not typically used as a first-line imaging modality for evaluating SI pain, it can be considered in certain cases to assess specific underlying conditions.

No comprehensive guidelines for SI pain have been provided yet. Routinely, conventional radiography represents the first-line modality in most instances and serves as a useful baseline for future comparison; however, the absence of radiographic changes does not exclude an underlying process and many patients with suspected inflammatory back pain usually proceed to further imaging, in particular MRI (9-10). In patients with suspected infection, contrast-enhanced MRI (CE-MRI) or planar or SPECT-CT isotope bone scintigraphy are the modalities of choice, with MRI offering better assessment of anatomical changes and periarticular soft tissue structures over SPECT-CT without ionizing radiation exposure (9-10).

MRI, CT, and isotope bone scintigraphy are all useful in the detection of stress fractures of the sacrum and pelvis. CT is helpful in situations in which there is a contraindication to MRI and provides excellent delineation of periarticular erosions, sclerosis, or osseous metastasis (9-10).

4. Diagnostic Injections: diagnostic injections, such as intra-articular anesthetic blocks or provocative SIJ injections, are considered the gold standard for confirming the diagnosis of SIJ-related pain; in fact, controlled injections into the SIJ can provide temporary pain relief, aiding in the accurate identification of the pain source.

These injections involve injecting an anesthetic (eg lidocaine) or a combination of anesthetic and anti-inflammatory medication into the SI joint in order to temporarily numb the joint and assess its involvement in the patient's pain symptoms: if the injection provides temporary relief of pain, it suggests that the SI joint is the source of the pain (11).

The diagnostic injections are performed under imaging (fluoroscopy and/or CT rarely under US or MRI) guidance in order to drive accurately the needle at the level of SI joint with patient in prone position; usually a local anesthesia is performed before needle insertion at the level of SI joints (11).

No more than 2.5 mL of injectate are recommended during an intra-articular diagnostic injection; in fact, extravasation of local anesthetic onto nearby neural structures theoretically compromises the specificity of the diagnostic injection (12-13).

Minimally invasive procedures

There are various nonsurgical treatment options available for sacroiliac joint SI pain, including pain medications such as nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy (PT), steroid injections into the SIJ, and radiofrequency ablation (RFA) targeting the sacral nerves.

For acute or subacute SI pain, a combination of NSAIDs, icing, and activity modification can be helpful in reducing pain (11). However, it's important to note that NSAIDs do not address the underlying disease process. Moreover, opioids have not been proven to be safe and effective for treating chronic SIJ pain, and their potential for addiction remains a significant public health concern.

The effectiveness of PT for treating chronic SIJ dysfunction and pain has not been demonstrated probably because of a paucity of high-level literature secondary to the great variability in the functional biomechanical deficit in patients with SI pain.

In this scenario, minimally invasive techniques can play a pivot role in SI pain management. Minimally invasive treatments aim to alleviate discomfort and improve functionality in the sacroiliac joint and enhance the overall quality of life for affected individuals. These techniques offer a targeted and minimally invasive alternative to surgical interventions, reducing morbidity, and optimizing resource utilization.

Sacroiliac joint injections

Sacroiliac joint injections involve the injection of local anesthetics, corticosteroids, or a combination of both into the SIJ. These injections aim to provide pain relief, reduce inflammation, and facilitate functional improvement. Various approaches, such as fluoroscopy-guided, CT-guided or ultrasound-guided injections, can be employed to ensure accurate

needle placement. There is no high-level evidence supporting the short- or long-term effectiveness of this treatment option.

Since there is no conclusive evidence supporting corticosteroid injections as superior to a placebo, the usefulness of trials using corticosteroid injections as an active control group is uncertain. No improvement in pain or function beyond 1 month with injections in 3 randomized control trials (RCT) evaluating SIJ injection versus radiofrequency (14-16). The cost-effectiveness of sacroiliac joint steroid injections has not been established.

There is a lack of evidence demonstrating long-term pain relief from this procedure, and the benefits of repeated injections have not been confirmed through studies.

Radiofrequency ablation

Radiofrequency ablation (RFA) involves the use of thermal energy to create lesions on the nerves supplying the SIJ, thereby interrupting pain signals. This minimally invasive procedure offers prolonged pain relief and has shown promising outcomes in patients with SIJ pain refractory to conservative management.

The analysis of RF ablation literature is constrained by the inconsistencies in patient selection criteria, the specific nerves chosen for ablation, and the diversity of RF ablation technologies and techniques employed. Four randomized trials, aiming to explain the effectiveness of radiofrequency (RF) ablation compared to sham procedures, have been published. Two studies indicate that RF ablation of the lateral branches of sacral nerve roots can provide temporary relief from SI pain (17-18). A one-year follow-up from one of the cooled RF ablation trials showed a moderate reduction in pain (19). In a smaller trial conducted by Mehta et al. (with a sample size of 30), RF ablation strip lesioning was compared to a sham procedure, resulting in significant improvement in Visual Analog Scale (VAS) and EuroQOL-5D scores at 3 months (20). A more recent study comparing heated RF ablation to a sham procedure demonstrated no significant difference in pain level or patient satisfaction at 1 or 3 months (21).

Additionally, there are three pragmatic RCTs comparing RF ablation to SIJ steroid injection demonstrating better clinical results in RFG groups (14-16). Moreover, SIJ RF ablation randomized against PT, the authors demonstrated no significant differences in pain level or patient satisfaction at 3, 6, 9, or 12 months (22). In the context of the Dutch healthcare system, RF ablation was determined to lack cost-effectiveness from a societal standpoint for patients experiencing chronic pain originating from the sacroiliac joint (23).

Prolotherapy and PRP injection

Prolotherapy involves the injection of biological substances, such as dextrose, into ligamentous tissue is believed to trigger a series of activities, from the influx of granulocytes, macrophages, and fibroblasts to the release of growth factors, finally leading to collagen deposition.

PRP injections utilize the patient's own concentrated platelets to promote tissue regeneration, reduce inflammation, and alleviate pain. PRP therapy has gained popularity as an adjunctive treatment for SIJ disease, particularly in cases of ligamentous laxity and degeneration. There are not RCT nor cost analysis related to those techniques.

A recent case series demonstrated that concentrated dextrose prolotherapy combined with platelet-rich plasma (PRP) injections has been successfully employed to treat lumbo-sacral spine osteoarthritis (OA) in elderly patients who had previously experienced ineffective results with conventional treatment approaches (24).

Minimally invasive fusion techniques

Minimally invasive fusion techniques, such as SIJ fusion using implants or bone grafts, provide long-term stabilization and pain relief for patients with severe SIJ dysfunction. These procedures aim to restore joint stability while minimizing tissue trauma and accelerating recovery:

- SI Joint Fusion with Implants: this technique involves the use of implants or devices designed to stabilize the SIJ. It typically requires a small incision and the insertion of screws, rods, or plates to fuse the joint. The implants help provide stability while the joint heals.
- SI Joint Fusion with Bone Grafting: in this approach, bone graft material is used to promote fusion between the sacrum and ilium. The graft material may be obtained from the patient's own body (autograft) or from a donor (allograft).

Minimally invasive techniques involve small incisions and the use of specialized instruments to prepare the joint and place the bone graft.

- SI Joint Fusion with Percutaneous Screws: percutaneous or minimally invasive screw fixation involves the placement of screws across the SIJ to provide stability and promote fusion. This technique requires small incisions and the use of image guidance to accurately position the screws (Fig. 3).

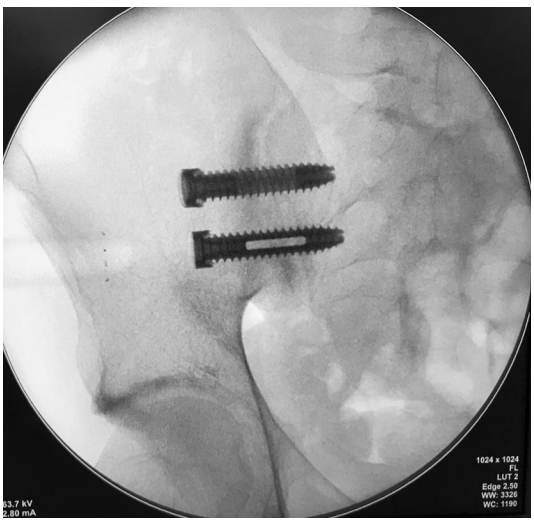


Fig. 3. Right side SIJ fixation, AP radiographic view: the lower screw inserted at the level of S2 shows fenestration, to facilitate bone integration.

The lateral approach has been demonstrated that minimally invasive lateral sacroiliac joint fusion (MIS SIJF) generally causes minimal changes in motion or stress at the opposite sacroiliac joint (contralateral SIJ), minimal increase in motion at the L4-L5 or L5-S1 motion segment, and a limited (5%) increase in stress at the hip joint (25-28).

In 2008, SI-BONE, Inc., obtained FDA clearance to market a porous-surfaced transiliac transfixing implant (TTI) for sacroiliac joint fusion (SIJF). Since then, different lateral transiliac transfixing devices have also received FDA clearance for minimally invasive lateral SIJF. The clinical evidence supporting the use of these devices has significantly expanded over the past decade. However, the majority of high-level clinical evidence regarding the safety, effectiveness, durability, and economic benefits of lateral minimally invasive SIJF is primarily derived from the use of the iFuse implant system (29-31).

These studies present compelling evidence supporting the safety and effectiveness of lateral transiliac minimally invasive sacroiliac joint fusion (MIS SIJF) using lateral transfixing devices. The findings consistently show significant improvements in pain levels, functional abilities, and quality of life (QOL). In both randomized trials, patients who underwent SIJF experienced considerably higher levels of pain relief, reduced disability, and improved QOL compared to those who received non-surgical treatment (32-40).

According to the International Society for the Advancement of Spine Surgery, Policy 2020 Update the MIS SIJF is not indicated in the case of (11):

- Less than 6 months of SIJ pain and/or functional impairment.
- Failure to pursue conservative treatment of the SIJ (unless contraindicated).
- Pain not confirmed with a diagnostic SIJ block.
- Presence of other pathology that would substantially prevent the patient from deriving benefit from SIJF.

EMERGING THERAPIES

Peripheral nerve stimulation

Peripheral nerve stimulation (PNS) involves the placement of electrodes near the nerves supplying the SIJ to modulate pain signals.

PNS is believed to provide pain relief by engaging the gate-control theory of pain, as originally described by Melzack and Wall (41). According to this theory, the excitation of inhibitory dorsal horn interneurons occurs through the stimulation of large-diameter, low-threshold, non-nociceptive Aβ fibers (42). These interneurons play a role in processing and transmitting nociceptive information from Aδ and C nerve fibers, effectively inhibiting the transmission of pain signals from the spinal cord to higher centers in the central nervous system (CNS). PNS also acts to reduce central sensitization and hyperalgesia by diminishing excessive peripheral nociceptive activity within the spinal cord. It achieves this by inhibiting wide dynamic range neurons in the dorsal horn and reducing Aβ fiber-induced activity within the medial lemniscal pathway in the brain. Additionally, animal studies have indicated that the analgesic effects of PNS may involve various pathways, including the serotonergic (5HT2, 5HT3), GABAergic, and glycinergic systems (43).

In a study involving patients with sacroiliac joint pain that did not respond to conservative measures and injection therapy, PNS was implemented, and the patients were followed for up to four years. The study observed significant reductions in average pain scores at one year (measured on the Visual Analog Scale) from 8.8 to 1.6, at two years from 8.8 to 1.9, and at three years from 8.8 to 2.0. By the fourth year, two out of three patients reported satisfaction with the placement of PNS (44). This emerging therapy offers a reversible and adjustable option for pain management, particularly for patients who have failed conventional treatments (40).

Biologic agents and stem cell therapy

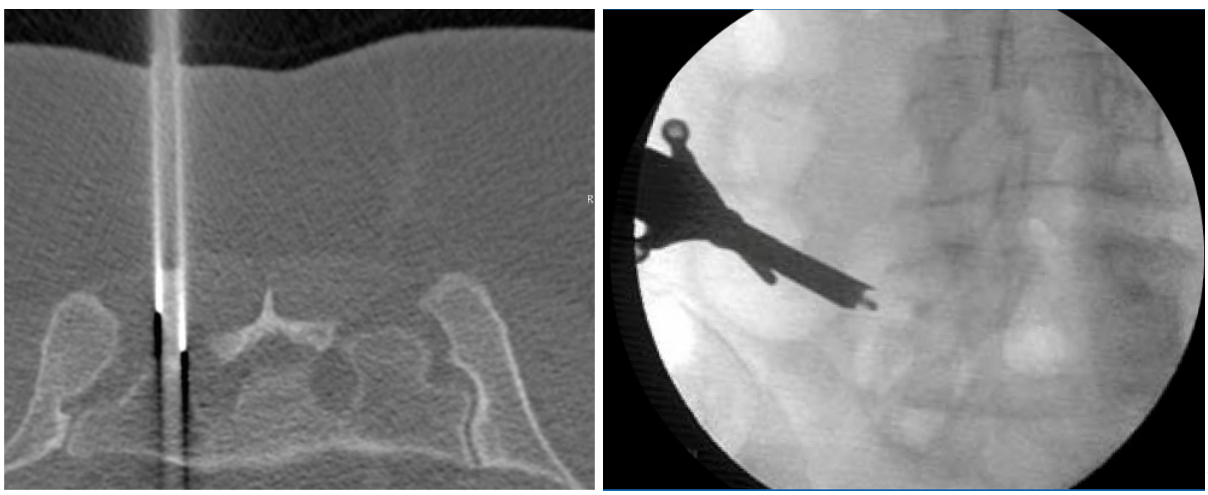
Biologic agents, such as anti-inflammatory cytokines, growth factors, or inhibitors of pain mediators, hold promise for the treatment of SIJ disease. These agents target specific pathways involved in inflammation and pain, providing a potential disease-modifying approach.

Among the different biologic agents, adult stem cells, often known as 'medical signaling cells' or 'mesenchymal stem cells' (MSCs), have been extensively studied. MSCs do not express major histocompatibility complex Class II (MHC class II) proteins, which makes them adaptable to various cell types and reduces the risk of treatment rejection. Their remarkable capacity to differentiate into specific cell types plays a crucial role in the healing process by providing the cells necessary for regeneration (45).

Stem cell therapy explores the regenerative potential of stem cells to repair damaged tissues and promote joint healing. Early preclinical and clinical studies have shown encouraging results, suggesting that stem cell therapy may have a role in the future treatment of SIJ disease. While there are a limited number of studies on the utilization of prolotherapy and biologics for treating axial spine pain, further research with stronger evidence is needed to determine the effectiveness of these therapies (45).

Endoscopic radioablation

Recently invented, Endoscopic radioablation seems to demonstrate more effectiveness in comparison to conventional single-needle RF ablation. The procedure consists in introducing two small working cannulas at the level of the lateral border of both S1 and S1 posterior sacral foramina (Fig. 4a), introducing through the cannula an extremely powerful electroknife together with optic fiber, scratching the lateral margin of the sacral foramina from where the SIJ nerve networks projects to the iliac bone (Fig. 4b), disconnecting the SIJ innervation (46-47).



A **B**

Fig. 4. *Endoscopic radioablation of the SIJ. Under CT-guidance, a working cannula is placed at the lateral margin of the posterior first sacral foramen (**4a**) and a RF probe is then inserted into, emerging at the level of the sacral bone (**4b**), performing strong ablation of the SIJ nerve network at the emerging area.*

CONCLUSIONS

Interventional treatments for SIJ disease aim to alleviate pain, improve functional capacity, and enhance the overall quality of life for affected individuals. These techniques offer a minimally invasive alternative to surgical interventions, reducing morbidity, and optimizing resource utilization. By precisely targeting the source of pain and providing therapeutic interventions, interventional treatments have become integral to the comprehensive management of SIJ disease.

Ongoing research into innovative therapies and technologies, such as targeted drug delivery systems, nanomedicine, and regenerative medicine, holds promise for the future management of SIJ disease. These advancements may offer novel approaches to pain relief, tissue regeneration, and joint stabilization.

Interventional treatments have revolutionized the management of sacroiliac joint disease, providing targeted approaches to pain relief, functional improvement, and joint stabilization. A comprehensive understanding of diagnostic techniques, minimally invasive procedures, emerging therapies, and their efficacy and safety profiles is crucial for informed decision-making and optimizing patient outcomes.

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