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Diagnosis and Current Treatments for Sacroiliac Joint Dysfunction: A Review

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Abstract The sacroiliac joint (SIJ) is a common pain generator for individuals with low back pain. Diagnosis and treatment of sacroiliac joint dysfunction is often a challenge due to the complex anatomy and biomechanics of the joint. In addition, patient presentation is often non-specific. The purpose of this review article is to provide a concise overview of the relevant anatomy, pathogenesis, diagnosis, and the current conservative as well as interventional treatments for SIJ dysfunction.

Keywords Sacroiliac joint · Pain · Diagnosis · Treatment

Introduction

The sacroiliac joint (SIJ) is a common pain generator for individuals with low back pain (LBP). The prevalence of SIJ pain has been reported to be up to 75 % [1]. History, physical examination, and imaging often have low sensitivity and specificity for the diagnosis of SIJ dysfunction. For these reasons, and also the complex anatomy and biomechanics of the joint, diagnosis and treatment often remains a challenge. The purpose of this review article is to provide a concise overview of the relevant anatomy, pathogenesis, diagnosis, and the current interventional treatments for SIJ dysfunction.

Anatomy and Biomechanics

The SIJ is formed by the articular surfaces between the sacral and iliac bones. The stability of the joint is maintained by the union of the two bones, along with numerous muscles and ligaments. The SIJ is the largest axial joint in the body at an average of 17.5 cm^2 [2]. Its shape and contour evolve throughout adult life, as its surfaces are initially flat but become angular as time elapses [3]. It is a true diarthrodial joint with articular surfaces surrounded by a fibrous capsule containing synovial fluid [4]. The two joint surfaces move correlatively together and are considered to be bicondylar joints [5]. A unique aspect of the SIJ is that the sacral surface is covered by hyaline cartilage whereas the ilial surface contains fibrocartilage [6]. It is also worth noting that only the anterior third of the sacroilial interface is a true synovial joint, as the rest of the joint contains predominately ligamentous connections.

The primary purpose of the SIJ is to maintain stability. This is accomplished through multiple mechanisms. There exists a ridge along the ilial surface and depression along the sacral surface which minimizes movement and enhances stability [7]. The primary mechanism, however, is through the expansive ligamentous network attaching to the SIJ. Because of the absence of a posterior capsule, the SIJ functions as a connecting band through its dorsal extension [8]. The ligaments contained in the SIJ include the anterior SI ligament, posterior SI ligament, interosseous ligament, sacrotuberous ligament, and sacrospinous ligament (Fig. 1). The most notable ligaments are the dorsal interosseous ligaments, which typically require more force to tear than a pelvic fracture. The posterior SI ligaments, which can be divided into long and short ligaments, function to keep the SIJ from opening by limiting the amount of SI flexion [9]. The long ligaments are commonly palpated to assess for pain by comparing one side of the body to the other. Because of the arrangements of the structure, the SIJ is six times more resistant to medially directed forces compared to the lumbar spine, but only has

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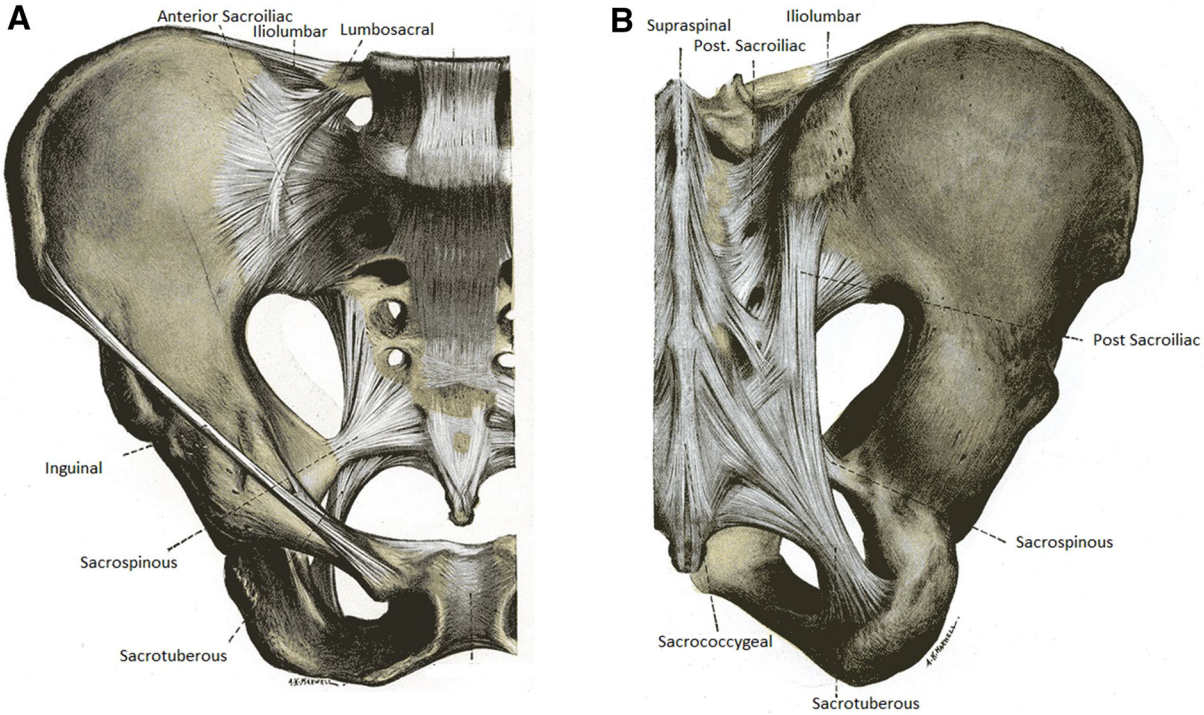

Fig. 1 Anterior view of articulations of the pelvis. From *Gray's Anatomy of the Human Body* (1918) plate: Anterior articulations of pelvis (Quain). **a** Anterior Sacroililac Joint. **b** Posterior Sacroiliac Joint (Source: *20th U.S. edition* of Gray's Anatomy of the Human Body)

1/20 the resistance in axial compression and ½ the resistance in rotation [10].

The muscles surrounding the SIJ serve to provide muscular forces, guide movement, and enhance stability to the pelvic bones. The primary muscles which connect to the SIJ ligaments include the gluteus maximus, piriformis, biceps femoris, and latissimus dorsi via the thoracolumbar fascia [11]. These muscles facilitate movement of the SIJ along three primary axes. These motions are limited to extremely small movements. Prior studies demonstrated that motions rarely exceeded 3 degrees in each axis in normal patients [12••].

The innervation of the SIJ has been a consistent topic of debate over the past few decades. Several prominent studies examining the innervation have obtained unreliable results. Some have claimed that the posterior SIJ is innervated by the lateral branches of L4–S3 dorsal rami [2], while others believe L3 and S4 have contributions as well [13]. The anterior SIJ is believed to be innervated by L2–S2 ventral rami [2]. One study stratified further by claiming the superior ventral SIJ is innervated by the ventral ramus of L5, and the inferior ventral portion is innervated by the ventral ramus of S2. The same study concluded that the superior dorsal portion is innervated by the dorsal ramus of L5, while the inferior dorsal portion is supplied by the dorsal rami of sacral nerves [14]. In contrast there have been claims that the entire SIJ is derived from the sacral dorsal rami [15]. There have even been claims that the anterior SIJ does not contain nervous tissue [14]. These have all been major recent developments to strictly define the SIJ innervation pattern; however, there is much left to discover.

Presentation of SIJ Dysfunction

Signs and Symptoms

One of the most challenging aspects of diagnosing and treating SIJ dysfunction lies in its inconsistent presentation. SIJ pain can present through localized and/or referred pain. The most common complaints include pain in the lower back, buttocks, leg, groin, and hip [16, 17]. Symptoms such as increased urinary frequency and transient numbness/tingling have also been reported [18, 19]. The most common areas of referred pain are the buttocks (94 %), lower lumbar region (72 %), lower extremity (50 %), and groin (14 %) [20••]. The quality of the pain can range from dull and achy to sharp and stabbing [17, 21]. Aggravating factors include all types of physical activity, unspecified sustained positions, bending, climbing, rising, and sexual intercourse [16]. The most consistent factor for identifying SIJ pain is unilateral pain below L5 [20••, 22].

The inconsistent presentation of SIJ pain can be attributed to the presumably extensive innervation of the joint. Several muscle groups become involved, which can result in spasms as a predominant presentation [17, 21]. The most common presentations involving muscle groups include tightness of the hamstrings, quadriceps, and hip flexors.

Physical Examination

The physical examination of SIJ dysfunction is another challenging step towards diagnosis. Inspection rarely, if ever, shows asymmetry, protrusion, or erythema. Although unreliable, clinicians typically rely on provocative maneuvers to guide them towards a diagnosis. The most common tests include Patrick's test, which identifies SIJ pain during flexion, abduction, and external rotation, and Gaenslen's test, which applies hip extension and aggravates the SIJ [17, 21]. Some lesser known exams are the iliac gapping test and iliac compression test, which involve applying anterior pressure to the anterior superior iliac spine and lateral pressure to the uppermost iliac crest, respectively.

Although already mentioned, it must be emphasized that neither history nor physical examination findings are capable of producing reliable results [23, 24]. It has been demonstrated that 20 % of asymptomatic patients had positive findings on three common provocative maneuvers [25], and that these maneuvers have low interexaminer reliability [26].

Imaging

Imaging modalities have not proven to be much more beneficial than the physical examination. Bone scans and CT scans have both shown sensitivities ranging from 40 to 60 % [27, 28], while X-rays and MRIs rarely reveal abnormalities [17]. The most valid and reliable diagnostic modality lies in CT-guided local anesthetic injections, which can diagnose SIJ dysfunction when analgesia is achieved. Studies have typically used a 75 % pain improvement threshold before the SIJ is presumed to be the source of pain [28]. However, the specificities of these SIJ blocks have been extremely low [29]. SIJ injections are also difficult to localize into the joint space. One study showed that intraarticular injection was obtained only 22 % of the time without any spread [30]. Sacral foraminal spread occurred in 44 % of the patients and epidural spread occurred in 24 % [30], clearly indicating a lack of validity in the results obtained. It is worth noting that although the goal remains to localize injections in the intraarticular space, recent studies have shown that ligament injection posterior to the joint can yield greater pain relief than injection directly into the articular space [31]. With all the discrepancies present, more extensive research is necessary before we can confidently define a gold standard for diagnosing SIJ pain.

Treatment

Conservative Management

Activity Modification

In the acute phase of SIJ pain (1–3 days), relative rest and avoidance of aggravating factors of pain is recommended. Activities that involve a one-leg stance such as skating and running may increase the force in each SIJ and intensify the pain [32]. Because activities that aggravate the pain may be specific to the individual, it is crucial for each patient to find the activities which may increase or trigger the pain, particularly in those who have progressive or significant SIJ pain.

Once the recovery phase (3 days to 8 weeks) is reached, patients should be advised to maximize function with therapeutic exercises and physical therapy [33]. Goals of therapy may include: increasing mobility, stretching, strengthening, and correcting of any asymmetries and hyperactivity of muscle groups [32, 33].

In pregnant patients with hypermobility and laxity of the SIJ, excessive stretching and mobilization may aggravate SIJ pain [32, 34]. Therefore, clinicians should be extremely cautious with therapy or any exercise prescriptions for pregnant patients.

Physical Therapy

Physical therapy treatments for SIJ dysfunction usually emphasize the abdomino–lumbo–sacro–pelvic–hip complex. The treatments include: stretching, strengthening, stabilizing pelvic floor muscles, correcting gait abnormalities and addressing postural and dynamic muscle imbalance. An exercise program for SIJ dysfunction will include core strengthening and correction of muscle imbalances that may increase the shearing forces in one SIJ. A prior study evaluated five patients with sacroiliac dysfunction using electromyography, and found that there was abnormal hyperactivity of the gluteus muscle on the involved side as well as hyperactivity of the latissimus dorsi on the contralateral side [35]. After undergoing a therapeutic exercise program, the patients demonstrated normal muscle electrical activity and improvement in strength, with a reduction of shearing forces across the SIJ [35].

Other studies have attempted to elucidate the relationship between muscle imbalances and sacroiliac dysfunction. Massoud et al. [36] studied the association between

hamstring length and gluteal muscle strength in 159 patients with sacroiliac joint dysfunction. Subjects were divided into three groups: 53 patients with low back pain without SIJ dysfunction, 53 patients with SIJ dysfunction, and 53 normal persons without low back pain. Hamstring muscle length and gluteal muscle strength was measured in all subjects. Gluteal muscle weakness was found to be more common in patients with SIJ dysfunction (66 %) in comparison with LBP without SIJ dysfunction (34 %). In patients with SIJ dysfunction with gluteal muscle weakness, hamstring muscle length was shorter in comparison with SIJ dysfunction subjects without gluteal muscle weakness [36].

Manipulation

Manipulation is another conservative intervention for management of SIJ dysfunction. Kamali and Shokri [37] compared the outcomes of two manipulation techniques in patients with sacroiliac dysfunction. Thirty-two patients with sacroiliac dysfunction were randomly divided into two groups; one group received high-velocity low-amplitude (HVLA) manipulation to only the SIJ and the other group received manipulation to both the SIJ and lumbar spine. Both groups showed significant improvements in visual analogue scale (VAS) and Oswestry Disability Index (ODI) at 48 h and 1 month after treatment, with no difference between the groups [37].

Fernandes [38] evaluated the effectiveness of Mulligan mobilization with movement (MWM) in 60 patients and found that patients who received the treatment had reduced pain (VAS) and disability (ODI).

Modalities

Modalities may also be an effective adjuvant to sacroiliac pain treatment. Some modalities that may be used during treatment include: ultrasound with or without phonophoresis, diathermy, moist heat or cold, and TENS (transcutaneous electrical nerve stimulation) [38]. One prior study attempted to evaluate the effectiveness of ultrasound and long wave diathermy in patients with sacroiliac joint dysfunction in 50 subjects. One group received ultrasound (1 MHz, 1 W/cm^2, 5 min) and the other group received long wave diathermy (12 min and 7 J of energy). The study demonstrated that both ultrasound and diathermy were beneficial in decreasing pain, improving unilateral lower limb stance time and reducing ODI scores [39].

Orthosis

Stabilization of the SIJ with an orthosis can be a valuable adjunct to pain management in the patient with SIJ dysfunction. The SIJ compression belt modifies the activation patterns of muscles in patients with SIJ dysfunction. Jung et al. [40] found that the electromyography (EMG) amplitude of the biceps femoris was remarkably reduced in the patients with SIJ pain using a pelvic compression belt compared to patients without SIJ pain. Through modification of the muscle activation patterns, it may provide stability to the SIJ. Vleeming et al. [41] demonstrated in pelvic–spine preparations that a sacroiliac belt provided stability to the pelvis and is a reliable treatment for pelvic instability caused by ligamentous damage in multiparous women. Monticone et al. [42] found that patients treated with a sacroiliac belt combined with stabilizing exercises reduced symptoms of SIJ dysfunction.

Medication

NSAIDs (non-steroidal anti-inflammatory drugs) are usually considered as the first line medication for SIJ pain. A Cochrane systematic review of 51 RCT showed that patients with acute low back pain had symptomatic pain relief with NSAID treatment [43]. Several randomized control trial studies showed the effectiveness of NSAIDs in treatment of acute low back [44–46]. In addition, NSAIDs are the first line treatment of sacroilitis with inflammatory etiologies such as ankylosing spondylitis (AS) and undifferentiated spondyloarthritis. A significant proportion of AS patients showed significant clinical improvement with NSAID treatment [47]. The anti-inflammatory effects of NSAIDs are the reason for improvement of pain AS patients [48]. Ankylosing spondylitis (AS) patients have a decrease in CRP level after 12 weeks treatment with COX 2 inhibitors [49].

Interventional Management

Injections

Injection therapy may provide both diagnostic and therapeutic utility in the management of SIJ dysfunction. As mentioned previously, the most valid and reliable diagnostic modality lies in image-guided local anesthetic injections. For therapeutic purposes, SIJ injections have moderate evidence for efficacy, demonstrated through prospective observational studies and randomized controlled trials.

For prospective observational studies, Maugars et al. [50••] performed 42 steroid injections on 22 patients and demonstrated that 79.2 % of procedures had a good response to the injection. Only 14 % of the joints injected had <50 % relief. Bollow et al. [51] performed 103 steroid injections on 66 patients and demonstrated that 92.5 % of patients had significant improvement of pain, and the improvement

lasted for 10 ± 5 months. Braun et al. [52] performed steroid injections on 30 patients and demonstrated that 83 % of patients had significant improvements of pain with duration of relief 8.9 ± 5.3 months. Gunaydin et al. [53] performed steroid injections in 16 SI Joints in nine patients and found that seven of nine patients had subjective improvement that lasted a mean of 10.8 ± 5.6 months.

There are a few randomized controlled studies for SIJ injections as a treatment modality for SIJ dysfunction. Maugers et al. [54] performed a double blind placebo controlled trial in 10 patients where 13 total joints were injected, six were injected with steroid, and seven with normal saline. At 1 month, 5/6 sacroiliac joints injected with corticosteroid described a relief of >70 %, in comparison to 0/7 of the placebo group. Six of the seven placebo patients were injected with steroid at 1 month, and at 1 month follow up, 85.7 % were assessed as having a good result. Luukkainen et al. [55] performed a randomized controlled study where 13 patients received steroid injections of the SIJ, while 11 patients received normal saline injections with lidocaine. At 1 month follow-up, the steroid group had decreased VAS scores and pain index.

Radiofrequency Procedures

Radiofrequency denervation procedures provide a minimally invasive technique for pain relief from SIJ dysfunction. Effectiveness of RF in patients with refractory SIJ pain has been reported by many studies, but these studies utilized a vast variety of subject selection, outcome measurement and technique.

Vallejo et al. [56] conducted a prospective case series in 22 patients with refractory sacroiliac pain who received pulsed radiofrequency denervation of the medial branch of L4, posterior primary rami of L5, and lateral branches S1 and S2. Sixteen patients had significant pain relief (successful rate was 72.7 %) and they had improvement in all QOL scores. Failure rate was 26.1 % (six patients with less than 50 % pain relief in VAS) [56].

Ferrante et al. [57] conducted a prospective study where RF ablation was performed intraarticularly for SIJ pain in 33 patients. Outcome measures included visual analog scale (VAS), physical examination findings, pain diagrams, and opioid usage. A successful RF ablation was at least 50 % reduction in SIJ pain for more than 6 months, and 36.4 % of subjects met the criteria.

Burham and Yasui [58] conducted a prospective study evaluating the therapeutic effect of RF strip lesioning adjacent to the lateral dorsal foraminal aperture with conventional monopolar lesioning at the L5 dorsal ramus in nine subjects. Eight patients had a significant relief of pain after the procedure (89 % successful rate) while 67 % of patients had pain relief 1 year after the procedure [58].

There have been several studies that demonstrated the efficacy of L4 and L5 primary dorsal rami and S1–S3 lateral branch radiofrequency denervation for SIJ pain [59••, 60, 61]. Cohen et al. conducted a randomized placebo-controlled study in patients with suspected SIJ pain. Fourteen patients underwent lower lumbar primary dorsal rami and sacral lateral branch cooled radiofrequency denervation, while 14 patients received local anesthetic block. The study demonstrated that patients who underwent the radiofrequency denervation had intermediate pain relief and functional improvement [60]. The subjects who had no response to placebo injections were crossed over and treated with conventional RF denervation. The successful criteria were 50 % or greater pain relief and significant functional improvement. One, 3 and 6 months after the procedure, the success rates for ages older than 65 years are associated with the failure of radiofrequency denervation for SIJ pain [62]. In addition, cooled probe RF in comparison with conventional RF was more effective for SIJ pain relief [62].

Surgery

Surgical intervention for sacroiliac joint pain is usually considered if pain is refractory to other treatment options and if there is significant osteoarthritis, instability, fracture, or infection. Discussion of the surgical treatments for fractures and infection is out of the scope of this review article.

A prospective study by Wise and Dall [63] in 13 patients regarding the safety and effectiveness of SIJ arthrodesis for pain demonstrated that patients who underwent the procedure had a high fusion rate and significant improvements in low back and leg pain, and dyspareunia. Average improvement was 4.9 on VAS for low back pain, an average of 2.4 for leg pain and 2.6 for dypareunia. Seventeen of 19 patients (89 %) had fusion evidence in radiological imaging [63]. A study by Waisbrod et al. [64] followed 22 patients with overt degenerative SIJ disease who underwent SIJ arthrodesis for 12–55 months, which resulted in a 70 % success rate with the surgery [64]. There is a case series by Buchowski et al. [65] where patients with SIJ dysfunction (13 patients), osteoarthritis (five patients), and spondyloarthropathy (one patient) and sacroiliac joint instability (one patient) were treated with arthrodesis. Radiological assessment and clinical improvement (36-item Short-Form, SF-36) were outcome measures. All 20 patients had significant improvement found both in clinical improvement and fusion rate [65].

Conclusion

The SIJ is a complex joint that is a common pain generator for low back pain. Patient presentation is often nonspecific and diagnostic physical examination maneuvers have low diagnostic value. The current gold standard for diagnosis is the performance of a diagnostic block. Treatment options include: activity modification, physical therapy, modalities, orthosis, manipulation, injections, radiofrequency procedures, and surgery. Because of the complex anatomy and biomechanics of the joint, diagnosis and treatment will likely continue to remain a challenge.

Compliance with Ethics Guidelines

Conflict of Interest B. Hamidi-Ravari declares no conflicts of interest. S. Tafazoli declares no conflicts of interest. H. Chen declares no conflicts of interest. D. Perret declares no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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