Sacroiliac Joint Dysfunction

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Learning Objectives
- Acknowledge the contribution and prevalence of SI joint pain and dysfunction in patients presenting with low back pain.
- Understand the basic anatomy and mechanics of the SI joint.
- Identify clinical history of patients with SI joint dysfunction and learn necessary physical examination components needed in order to facilitate a diagnosis.
- Develop a diagnostic and treatment algorithm in order to adequately diagnose and manage SI joint dysfunction.
- Understand the treatment options for patients presenting with SI joint injection, including both surgical and nonsurgical modalities.

44.1 Introduction

Low back pain remains a significant burden on the healthcare system, resulting in approximately 12 million physician office visits per year in the United States. It is among the leading causes of disability, accounting for expenditures in excess of $80 billion dollars every year [1–3]. Current surgical treatments of low back pain have demonstrated variable success rates. This suggests that the etiology of back pain is complex, often multifactorial, and frequently not clearly known, or that treatments provided inadequately address pain generators.

Sacroiliac joint (SIJ) pain is a difficult problem with a negative impact on quality of life [4], and is becoming increasingly recognized for its role in low back pain. In certain circumstances, SIJ pain may present as an isolated condition. However, in many scenarios, the SIJ represents one of many factors contributing to axial back pain and its various referral patterns. Studies have shown that SI pathology may either present in association with, or contribute directly to, the etiology of back pain in 15–30% of cases [5–9]. In spite of this, the SIJ is often overlooked as a contributing source of back pain.

Maintaining an index of suspicion, as well as a thorough understanding of the relevant anatomy, biomechanics, and clinical presentation involved in SIJ-mediated pain are required for accurate diagnosis. This chapter presents a comprehensive review of SIJ anatomy, pathology, and diagnostic algorithms, as well as current surgical and nonsurgical treatment options and techniques for SIJ dysfunction.

Key Point
- SI joint pain may contribute to the etiology of low back pain in up to 30% of cases.

44.2 Background

Successful management of low back pain requires recognition and appropriate management of the pain source. Studies have shown that the cause of low back pain may not only have variable lumbar origins, but may also be a manifestation of hip or SIJ etiology as part of a kinetic chain. In a review of over 1200 cases, 44% of individuals presenting with low back pain had findings consistent with lesser-recognized diagnoses such as SIJ and posterior facet syndromes [6]. An additional 33% of patients in their cohort had concordant SIJ symptoms in addition to lumbar stenosis or spondylolisthesis. Further work has shown that of patients presenting to spine clinics for back pain, only 65% have a singular pain generator localized to the spine; and 15–30% have pain that involves to some degree the SIJ [5–9].

Key Point
- Rate of SI degeneration is increased in patients who have undergone prior lumbar or lumbosacral fusion.

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Adjacent segment degeneration in instrumented lumbar or lumbosacral fusion is well documented. Unsurprisingly, adjacent segment degeneration of the SIJ also occurs. In a prospective cohort, the rate of radiographic findings consistent with SIJ degeneration was nearly double in patients who had undergone posterior spinal fusion compared to age-matched nonfusion controls followed over a 5-year period [10].

Finite element analysis simulating the effects of lumbar fusion has demonstrated increased force transmission across the SI joint as well as increased angular motion and stress at the articular surface following lumbosacral fusion [11]. Increased forces acting at the SI joint articular surface following lumbosacral fusion may serve to precipitate degeneration, as evidence demonstrates that three-level lumbar fusion may result in up to 30% incidence of SIJ degeneration over 4 years [12].

44.3 Anatomy and Biomechanics

The SIJ is the largest axial joint in the human body, with an average surface area of approximately 17.5 cm^2 [13–15]. Appreciation of the complex anatomy is critical to making a diagnosis of SIJ dysfunction. As first described in 1864, the SIJ is characterized as a true synovial joint [16] despite the fact that over 70% of its surface area is comprised of capsular and ligamentous structures. A thick layer of hyaline cartilage covers the sacral side of the SIJ. The thinner covering of the iliac surface, though commonly described as fibrocartilage, contains chondrocytes with type II collagen, making this surface a variant of hyaline cartilage [17]. These surface differences may increase the likelihood of SIJ degeneration [18].

The SIJ undergoes significant morphologic changes throughout life. Development is complete by early adulthood with formation of an auricular or C-shaped articular joint whose final anatomic orientation varies substantially across individuals (Fig. 44.1). Degenerative changes are common over the course of adulthood and have a predilection for the iliac side of the joint first, followed by sacral involvement. It should be stressed, however, that nonspecific degeneration is common, with more than 2/3 of asymptomatic older adults showing radiographic changes consistent with SIJ degeneration [19].

The SIJ capsule is primarily located in the anterior third of the joint and has a distinct synovial membrane, lined by a thin capsule and overlying ligament that are confluent with the iliolumbar ligament. There is no synovial membrane posteriorly. The interosseous ligament and the dorsal ligaments, which function as a tension band, form a functional dorsal capsule of the SIJ. The sacrospinous and sacrotuberous ligaments contribute to this dorsal capsule (Fig. 44.1). Additional secondary stabilization is provided by the dynamic function of the gluteus maximus and medius, erector spinae, biceps femoris, psoas, and piriformis muscles, as well as the lumbodorsal fascia [14]. These structures allow indirect transfer of regional muscle forces to the SIJ, and, in many cases, have expansions that invest with the posterior sacroiliac ligament structures. The structural integrity of the capsular and ligamentous structures is at least partly gender-specific, with hormonally-induced increased laxity in females allowing for additional necessary pelvic motion during parturition [20–22].

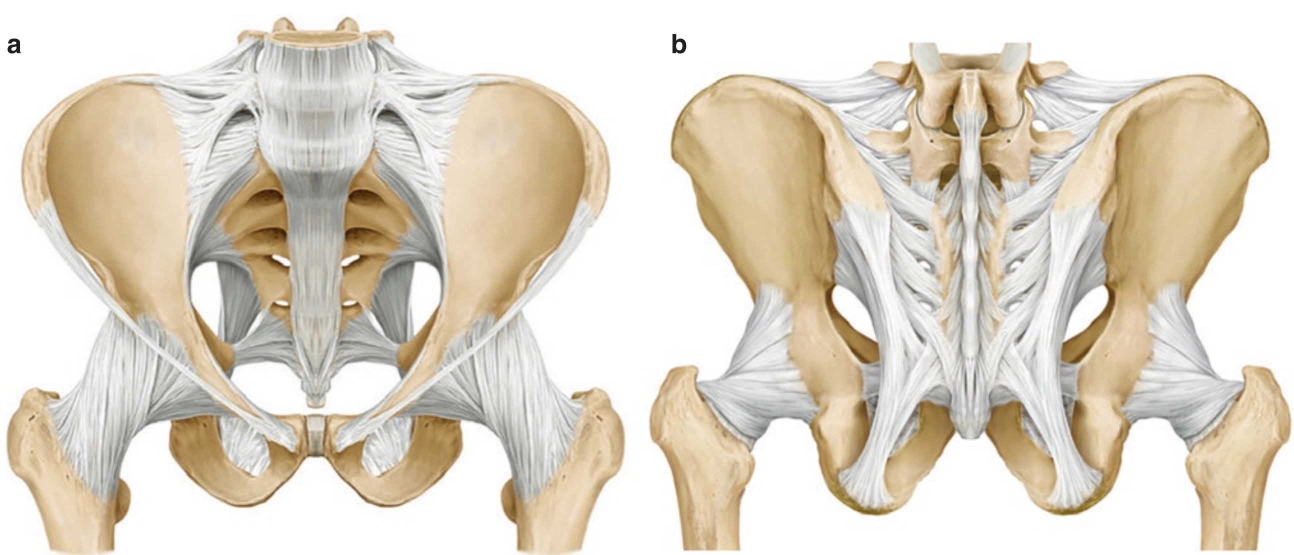

Fig. 44.1 Anatomy of the sacroiliac joint. (**a**) Anterior ligamentous and capsular structures. (**b**) Posterior ligamentous and capsular structures. (*Gray's Anatomy,* Elsevier)

The sacrum is considered the keystone of the pelvis. It is the most caudal component of the vertebral column and provides the transition from the spinal axis to the pelvis. It is critical in the transfer of load from the lower extremities and pelvis to the lumbar spine. The SIJ is six times stronger in lateral compression than the lumbar spine, but fails at one-twentieth the axial load and one-half the shear force [23].

Although the SI joints have historically been classified as static, there is a small but critical amount of motion. SI joint motion occurs around all three axes and is referred to nutation and counternutation. Nutation involves anterior rotation of the sacrum with posterior rotation of the ilium relative to the sacrum. Counternutation refers to posterior rotation of the sacrum with resultant anterior rotation of the ilium relative to the sacrum (Fig. 44.2). The amount of motion is small and often difficult to measure, but is on average less than four degrees of rotation [24–26]. Nutation and counternutation of the SI joints is also associated with medial and lateral translation of the ilium, respectively, typically measuring an average of 1.5 millimeters. Nutation is critical in preparation for increased pelvic loading, and contributes to tightening most of the SI joint ligaments which results in medial translation of the ilium and increased compressive forces across the SI joint, thereby controlling shear forces and facilitating joint stabilization. Conversely, counternation of the SI joints is typically encountered in situations during which the pelvis is unloaded, such as when lying supine. Interestingly, the degree of SIJ motion has not been shown to correlate with the presence of SIJ pain [20].

Several biomechanical models have been proposed to account for the seemingly paradoxical concepts of inherent anatomic structural stability and motion that govern the SI joints relative to the pelvis and lumbar spine. In upright posture, lumbopelvic compressional forces are necessary for stability at the expense of mobility. The concepts of form and force closure have been introduced to illustrate the importance of sustaining SI joint stabilization. Form closure refers to the theoretical stability in a joint with closely fitting surfaces, as may be anticipated with the tongue-in-groove association between the sacrum and ilium, in which no additional forces are necessary to maintain stability. In this situation, however, a "perfect" fit would make mobility practically impossible. The concept of force closure leads to SI joint compression, in which both dynamic lateral forces and friction are utilized to withstand vertical loads.

The structural features contributing to SI joint stability via form closure include the keystone configuration of the sacrum with dorsocranial "wedging" into the ilia, complementary ridges and grooves of the articular surfaces of the SI joints, as well as the integrity of the vast binding ligamentous complex. Additional force closure via the altered joint reaction forces generated by the dynamic network of ligaments, fascia, muscle, and ground reaction forces generate perpendicular compressional forces to add further stability to the SI joints. The combination of form and force closure leads to an effective model of SI joint accommodation, balancing friction, and compression in the joint to provide critical stability but also allow for necessary motion. The simultaneous counter-opposing states of stability and flexibility place conflicting demands on SI joint construction, but the appropriate balance of these states allow for effective and efficient force transfer between the trunk, pelvis, and lower extremities.

In a series of lectures from 1860 thru 1862, John Hilton observed that a nerve that both crosses a joint and innervates the muscles crossing and acting on a joint also innervates the joint [27]. The complexity and ambiguity of SIJ innervation is in part based on Hilton's Law. Various

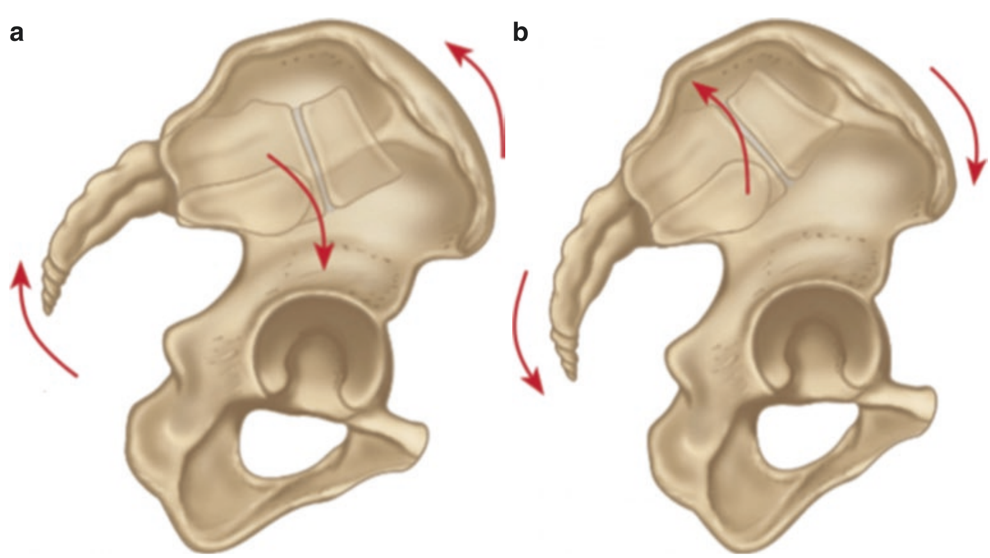

Fig. 44.2 SI joint motion patterns are referred to as nutation and counternutation. (**a**) Nutation involves anterior rotation of the sacrum with posterior rotation of the ilium and is associated with medial translation of the ilium. (**b**) Counternutation involves posterior rotation of the sacrum with anterior rotation of the ilium and is associated with lateral translation of the ilium

macroscopic, histologic, and immunohistochemical studies have demonstrated that the SIJ is highly innervated, with multiple nociceptors and mechanoreceptors present [28]. The synovium and capsule contain unmyelinated nerve endings for pain and temperature. The nerve supply to the posterior joint originates from either L4 to S3 root dorsal rami branches or independent contributions from the L3 and S4 nerve roots [29, 30]. The anterior joint similarly has significant variability with innervation supplied by the ventral rami from L2 to S2 roots [13]. Additional animal studies have evaluated the various pain thresholds of the nociceptive fields involving innervations of the lumbar facet articulations, SIJs, and lumbar disc. Pain sensitivity measured as mechanical threshold was 70 grams for the SIJ, which was significantly greater than the lumbar facet (6 grams), and less than the lumbar disc (241 grams) [31, 32].

Relevant surrounding neurologic anatomy consists of the L5 ventral ramus and lumbosacral plexus, which cross the cephalad portion of the SIJ approximately two centimeters distal to the pelvic brim [33]. The L5 root then courses along the anterior aspect of the sacral ala. The S1 ventral ramus crosses the SIJ more caudally, near the inferior aspect of the joint.

44.4 Pathology

SIJ dysfunction, a term commonly used to describe pain and disability related to poor functioning of the SIJ, has multiple etiologies. SIJ dysfunction may result from capsular or synovial disruption, ligamentous tension, altered joint mobility and stress, microfracture, or disruption in the myofascial kinetic chain. Pathology may be categorized as either intra- or extra-articular. Common causes of intra-articular pathology include infection, inflammation, and degenerative or inflammatory arthritis. The most common infectious organisms include *Staphylococcus, Pseudomonas*, *Cryptococcus*, and *Mycobacterium* and should be suspected in intravenous drug use, endocarditis, or posttraumatic situations [14]. Degenerative changes occur over the course of decades and are related to repeated microtrauma, ultimately presenting as a progression of joint sclerosis on imaging studies. Far more rarely, unilateral or bilateral sacroiliitis can be an early symptom in the seronegative and HLA-B27-associated spondyloarthropathies, occurring in individuals diagnosed with ankylosing spondylitis. There is a strong male predilection for the inflammatory spondyloarthropathies, and the association with HLA-B27 supports an immune-mediated etiology that is characterized by more erosive changes on radiographs (Fig. 44.3). These cases must be identified and distinguished from degenerative changes so that they can be referred for the appropriate nonsurgical management [34].

Extra-articular pathology, often posttraumatic, may be attributable to ligamentous injury, myofascial pain, and fractures. The underlying causes are numerous, including leg length discrepancy, gait abnormalities, prolonged exercise, athletic injuries, and prolonged lifting and bending [13]. In a retrospective study of 54 patients with injection-confirmed SIJ pain, trauma was the cause in 44% of cases, 35% were idiopathic, and 21% were due to repeated stress [35]. The most common traumatic events were categorized as motor vehicle accidents followed by falls. In young adults, major trauma resulting in SIJ disruption is most common, with lateral compression injuries more likely to result in later development of SIJ dysfunction [36]. Cumulative microtrauma from overzealous activity and repetitive loading, microfracture, and ligamentous or capsular injuries may also commonly cause insidious onset of SIJ pain.

Additional common causes of SIJ pathology may arise from iatrogenic injury due to overaggressive iliac crest graft harvest that inadvertently violates the SIJ or dam-

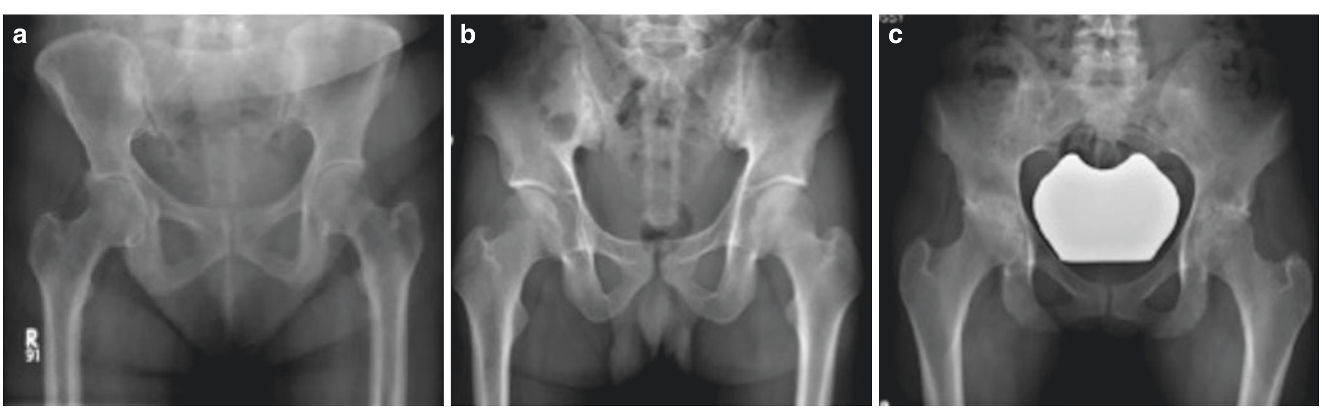

Fig. 44.3 (**a**) Degenerative changes within the SIJ with dense sclerosis and osteophytes. (**b**) Inflammatory changes in the SIJ with bilateral erosive sacroiliitis. (**c**) Complete fusion of the SIJ

ages the iliolumbar ligament [37]. Increasingly recognized in females, hormonal changes during the final trimester of pregnancy may induce hypermobility of the SIJ that predisposes it and surrounding ligaments to additional injury, resulting in chronic pain and instability. There is evidence that a prior history of lumbar fusion contributes to biomechanical and anatomical alteration of the SIJ [10, 11]. Metabolic diseases such as calcium pyrophosphate crystal deposition disease, gout, hyperparathyroidism, and renal osteodystrophy may potentiate early inflammation and degeneration [14]. Although primary sacroiliac tumors are rare, bony metastasis to the pelvis ranks second only behind spinal metastasis and must be ruled out.

44.5 Diagnosis

Although often perceived as challenging, diagnosis of the SIJ as a pain generator is possible through a combination of history, physical examination, and diagnostic SIJ block. The importance of the clinical exam may be a "paradigm shift" for surgeons who rely primarily on imaging for orthopedic diagnoses, since imaging often plays minimal role in the diagnosis of SIJ pain. Because SIJ pain referral patterns vary and can overlap with those of other pathologic conditions, the SIJ should be kept in mind when evaluating patients with chronic low back, buttocks, and hip pain.

44.5.1 Clinical History

Patients with SIJ complaints may present with a constellation of variable, and sometimes inconsistent, pain complaints in the lumbosacral region. Pain is usually off-center below L5 in the area of the posterior superior iliac spine (PSIS), with radiation into the buttocks, or, less commonly, into the groin. Pain in the legs above the knee is relatively common; pain below the knee is less commonly reported. Patients with SIJ dysfunction commonly point to an area just medial to and inferior to the PSIS (the insertion of the long dorsal ligament), which is deemed a positive Fortin finger test [38].

Patients frequently report pseudoradicular pain, numbness, tingling, and weakness in the distribution of the L5 and S1 nerve roots. However, physical examination typically demonstrates no true neurologic deficit. SIJ arthrography has shown a high proportion of patients with anatomic connections along the dorsum of the SIJ underneath the ligaments between the SIJ and the S1 neuroforamen or S1 nerve root [39]. Likewise, an anatomic connection is frequently demonstrated between the anterior SIJ capsule and the L5 nerve root/lumbar plexus. Finally, the same segmental spinal nerves innervate a variety of structures in the low back, pelvis, and proximal legs and potentially can cause pain referral patterns from these structures due to convergent sensory pathways. Together, these anatomic findings may explain pseudoradicular pain in patients with SIJ dysfunction (Fig. 44.4).

Fig. 44.4 Illustration of common SI joint pain referral pattern often manifests in a radicular pattern

Typical complaints include pain with activities that preferentially load the involved SIJ, most commonly sitting for prolonged periods, rolling over in bed, sleeping on the affected side, passing over road bumps while driving, or getting in and out of a car or chair. Activities that offload the affected SIJ typically lessen SIJ pain. In prospective studies of patients undergoing surgical intervention, subjects reported the common occurrence of radiating leg pain, groin pain, pain worse with sitting (especially on the affected side), rising, walking, and climbing stairs. Pain occurs during stance phase of gait. However, no specific aspect of the patient history is considered diagnostic of SIJ pain; rather clinical history is one component of the overall patient evaluation.

44.5.2 Physical Exam

Physical examination of the SIJ should involve a comprehensive evaluation of the lumbar spine, pelvis, and hips. Patient stance and gait patterns are evaluated, paying particular attention to overall postural balance. Because of the complex nature of referred pain patterns, routine lumbar examination should be carried out to include a focused neurological exam. Similarly, dedicated examination of the hips is also necessary.

Focused examination of the SI joints is based largely on provocative maneuvers that stress the SIJ. These tests, which are seamlessly incorporated into a standard lumbar spine and hip examination, include pelvic compression and distraction, FABER (or Patrick's) test, thigh thrust, and Gaenslen's test. These tests are performed with the patient supine on an examination table and involve provocation of the affected SI joint. A maneuver is considered positive if the test reproduces the patient's pain with localization to the SI joint.

Inter-rater reliability of physical examination maneuvers is high for most tests [40]. Although no single exam finding is perfectly correlated with presence of SI joint pain, various studies have shown that the occurrence of three or more positive provocative maneuvers increases the sensitivity and specificity for SI joint pathology to 91% and 78%, respectively [41]. The active straight leg raise test (ASLR) is another commonly used exam during which the supine patient is asked to rate the difficulty of actively raising the leg 20 cm off the examining table. During a positive test, pain localizes to the ipsilateral SIJ. This test may be used as an adjunct to provocative testing, and is frequently positive in women with peripartum pelvic pain attributed to the SIJ [42]. In one study of minimally invasive SIJ fusion, the ASLR improved in patients undergoing fusion but remained at baseline levels in patients undergoing nonsurgical treatment [43].

44.5.3 Imaging

Imaging is considered an important part of diagnosis of autoimmune sacroiliitis, being part of the New York Criteria for this condition [44]. Whether MRI is best for detecting early autoimmune disease is still debated [45]. However, in the more common setting of suspected degenerative SIJ dysfunction due to osteoarthritis or joint disruption, imaging is not necessarily correlative or diagnostic for SIJ pain [46]. Signs of osteoarthritis or degeneration on CT, which may include sclerosis, osteophytes, vacuum phenomenon, or subchondral cysts, are often prevalent in many patients without documented pain [19].

Key Point

- Imaging studies (including radiographs and CT) do not necessarily correlate with, and are not diagnostic of, degenerative SI joint dysfunction.

Although there is a slight predilection of degenerative imaging findings in patients with suspected SIJ pain, sensitivity and specificity of CT findings were low when compared to pain-free age matched controls [47]. In summary, no specific imaging finding has been shown to be diagnostic of SIJ pain. Imaging is therefore primarily used as a component of the diagnostic algorithm in the assessment of hip or spinal pathology, in addition to the evaluation of for possible inflammatory SIJ conditions.

44.5.4 Diagnostic Injection

As in most pain conditions, there is no gold standard for diagnosis of SIJ pain. The accepted reference standard for diagnosis of SIJ pain is an acute pain reduction in response to a fluoroscopically or CT-guided diagnostic intraarticular joint injection with a combination of radiographic contrast and local anesthetic. As with most spinal injections, it has been demonstrated that blind diagnostic SIJ injections are unacceptable, and that injections must be performed under imaging guidance in order to confirm intra-articular entry and spread in the anterior and lower two-thirds of the joint [15] (Fig. 44.5). While some aspects of SIJ injection require stan-

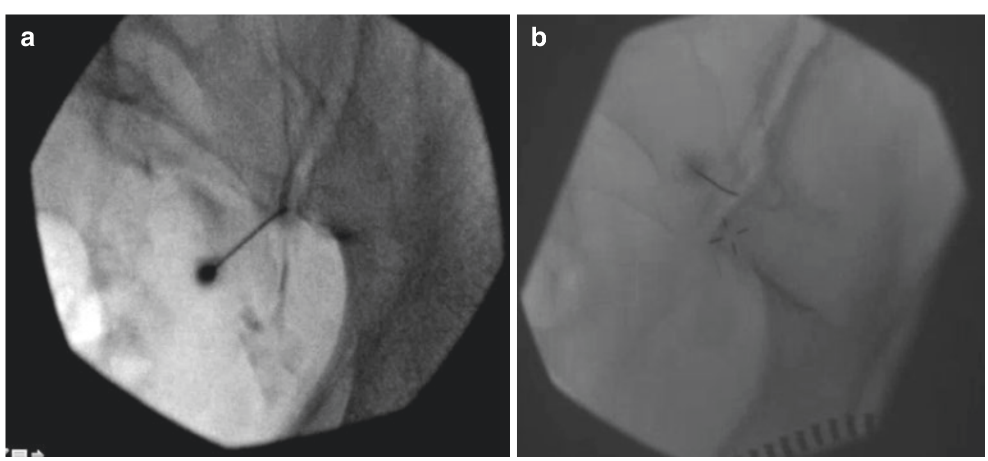

Fig. 44.5 (**a**) Anteroposterior fluoroscopic images demonstrating extravasation of contrast consistent with unsuccessful SIJ injection. (**b**) Anteroposterior fluoroscopic image shows desired intra-articular contrast spread following successful SIJ injection

dardization, it has generally been accepted that patients receiving at least 75% pain relief on a single injection confirms a significant component of pain that is specific to the SI joint. Recent evidence correlating surgical outcome to diagnostic block further demonstrates that even 50% of relief on a single injection serves as a successful prognostic tool and predictor of positive surgical outcome [48]. Even with image guidance, some studies have shown that false-positive and false-negative tests do occur [49]. False-positives may result from placebo effect, extravasation of local anesthetic to surrounding structures, or convergence of pain referral patterns. Conversely, false-negative results may be attributed to inadequate procedural technique in not achieving intra-articular location, failure of local anesthetic to reach symptomatic regions of the SIJ, or the presence of extra-articular pain sources. In the absence of a gold standard for diagnosis, injections serve as a critical reference standard of SI joint-specific pain, and should be used in conjunction with relevant clinical and exam findings to help arrive at a reliable diagnosis.

Key Point

- The accepted reference standard for diagnosis of SIJ pain is acute reduction in pain in response to an image guided SI injection.

Extra-articular SIJ blocks, which focus on anesthetizing lateral branches of sacral nerve roots, are often used to screen for SIJ-mediated pain potentially responsive to radiofrequency ablation. In one study, extra-articular blocks at multiple depths were able to mask pain due to probing the interosseous and posterior sacroiliac ligaments, but not pain elicited by distending the joint itself [50]. The study suggests not only dual innervation of the SIJ complex but also the probability of extra-articular pain generators.

44.6 Nonsurgical Treatment

Management of SI joint pain and dysfunction has traditionally involved nonsurgical treatment options, with variable success rates. While many episodes of often transient SI joint pain do resolve with nonsurgical treatment, management of chronic SI joint pain and dysfunction is often unpredictable and, unfortunately, unsuccessful.

44.6.1 Medication Management

Medications such as opioids and nonsteroidal anti-inflammatory agents (NSAIDs) may be useful for acute pain control. Newer agents including immunomodulators and protease inhibitors have shown success in management of inflammatory spondyloarthropathy but play no role in the more common degenerative and disruption-based SIJ syndromes. Moreover, no medical treatment has been shown to alter the course of SIJ pain due to degenerative sacroiliitis or SIJ disruption. As with other chronic pain syndromes, opioid abuse remains a significant concern.

44.6.2 Physical Therapy

Physical therapy for non-autoimmune SIJ pain is commonly employed and often a mainstay of treatment. The goals of therapy are to identify underlying functional deficits and provide improved flexibility and strengthening of stabilizing trunk muscles. Treatment is often combined with direct joint manipulation, while also educating the patient on optimizing biomechanics and activity avoidance to minimize symptoms exacerbation. In spite of trials that have shown some benefit with manual therapy and stabilizing exercises, [51–53] there is scant high-quality evidence that shows successful management of degenerative-mediated chronic SIJ pain with physical therapy. While physical therapy remains a reasonable nonsurgical option and is used as part of the standard management algorithm, evidence of effectiveness is modest at best, and its cost-effectiveness is uncertain.

44.6.3 Pelvic Bracing

Bracing with a pelvic belt, used in pregnancy-related pelvic pain, [54, 55] has also been described in the nonsurgical treatment of SIJ dysfunction, [56, 57] but no high-quality evidence exists to support its use.

44.6.4 SI Injections

Intra-articular and periarticular injections have been employed in the treatment of SIJ pain, with therapeutic effects related to the anesthetic and steroid phases of relief. Intra-articular SI injections may prove therapeutic as well as diagnostic, and are increasingly performed in the United States with variable success [58]. However, there is limited high-quality evidence to support their use. In a blinded randomized trial of periarticular steroid injections, women with pelvic pain after pregnancy attributed to SIJ dysfunction had improved pain levels, disability, 6-minute walk test, and isometric trunk extensor test results at 4 weeks after infiltration of 20 mg of triamcinolone around (but not into) the SIJ compared to after saline placebo [59]. Two small blinded randomized trials from a single group in Finland showed improvement in SIJ symptoms at 1 month after periarticular steroid infiltration compared to lidocaine injections [60, 61]. No high-quality study has shown long-term benefit from periarticular steroids.

44.6.5 Radiofrequency Ablation (RFA)

Radiofrequency (RF) ablation is also used to provide pain relief through denervation of the SI joint. Two high-quality blinded trials have shown short-term pain relief after RF ablation of lateral branches of sacral nerve roots [62, 63]. In these trials, patients were screened using diagnostic periarticular local anesthetic blocks. Twelve-month follow-up in one randomized trial showed moderate pain relief [64]. No high-quality evidence demonstrates long-term pain relief after RF ablation of the lateral branches of sacral nerve roots. The major shortcoming involving percutaneous RF ablation is that the ventral aspect of the joint cannot be addressed. Additionally, due to the complex innervation patterns, many of the nerves ablated during these procedures target other surrounding structures. And because much of the innervation supplying the SIJ originates from areas inaccessible to the RF probe, effectiveness is often limited and may contribute to the relatively high rates of return of SIJ pain following RF ablation.

44.7 Surgical Treatment

In appropriately selected patients who have failed conservative treatment, surgical management may be considered in the management of SI joint dysfunction. The treatment of choice is SIJ fusion (SIJF), with the goal of achieving arthrodesis and stabilization, thus allowing the spine-pelvis-hip complex to function more normally. Achieving these goals through surgical management has demonstrated long-term reduction in pain scores and overall improvement of function.

SI joint fusion was first described via an open surgical technique in 1908 [65], and there have since been numerous case series that have shown variable success following open SIJF [66–76]. Access to the SI joint may involve either an anterior, posterior, or lateral approach. The anterior surgical technique utilizes a standard ilioinguinal approach that allows access to the anterior synovial component of the SI joint, allowing for placement of bone graft and plate fixation, while also preserving the posterior ligamentous stabilizers of the SI joint [71]. Various posterior-based techniques have also been described, in addition to a modified lateral approach. While these options may be of greater familiarity to the surgeon, they typically offer only limited access to the more anterior-based articular surfaces of the SI joint, and often also require extensive debridement of the dorsal ligamentous structures, and may necessitate resection of a portion of the PSIS [76–79]. Various types of fixation have been described in conjunction with posterior SIJ fusion, including screws placed laterally from ilium to sacrum, [80] screws in the ilium and sacrum dorsally with a rod spanning the SIJ, [73] and hybrid fixation with a plate dorsally and screws laterally [70, 81].

Key Point

- Traditional open surgical techniques for SIJ fusion are associated with increased morbidity, including increased operative time and blood loss, lengthy postoperative hospital stays, increased risk of infection, and prolonged recovery times.

Open SIJ fusion techniques have historically resulted in lukewarm success, leading to modest rates of patient clinical improvement. The outcomes of open surgery have been further dampened by significant patient morbidity related to long operative times, increased blood loss, lengthy postoperative hospital stays and recovery times, as well as high rates of infection and pseudoarthrosis [82–84]. Additional complications related to injury to the erector spinae and other muscle insertions, as well as iatrogenic injury to the dorsal sensory nerve roots, sacral plexus, and internal iliac vessels have also been described. Radiographic fusion rates have been reported at 70%, with patient satisfaction rates approaching 60% [71]. However, with the advent of minimally invasive approaches, interest in open fusion has waned, and the open technique is now used primarily in the setting of acute trauma or revision surgery [85].

Recent advancements in surgical technology, along with a progression towards minimally invasive surgical (MIS) techniques, have resulted in the development and commercial availability of several devices used in MIS SIJF. Minimally invasive SIJF is predicated on a thorough understanding of the anatomy of the pelvis and sacrum, including bony architecture as well as the position of the neurovascular structures.

Three approaches similar to those used in open SIJF have been described for MIS SIJF. These include an anterior approach with endoscopic placement of a fusion cage [75] as well as reports of a dorsal approach with placement of fusion cages into the ligamentous portion of the SI joint, with limited success [81, 86]. The most commonly reported technique for MIS SIJF is the lateral transarticular approach, which was derived in part from modifications of the Smith-Petersen technique [66]. In this approach, devices are placed across the SIJ from lateral to medial under fluoroscopic guidance or navigational control using minimally invasive technique and principles (Fig. 44.6).

Although several devices are FDA-cleared for lateral transarticular SIJF, the majority of the published clinical lit-

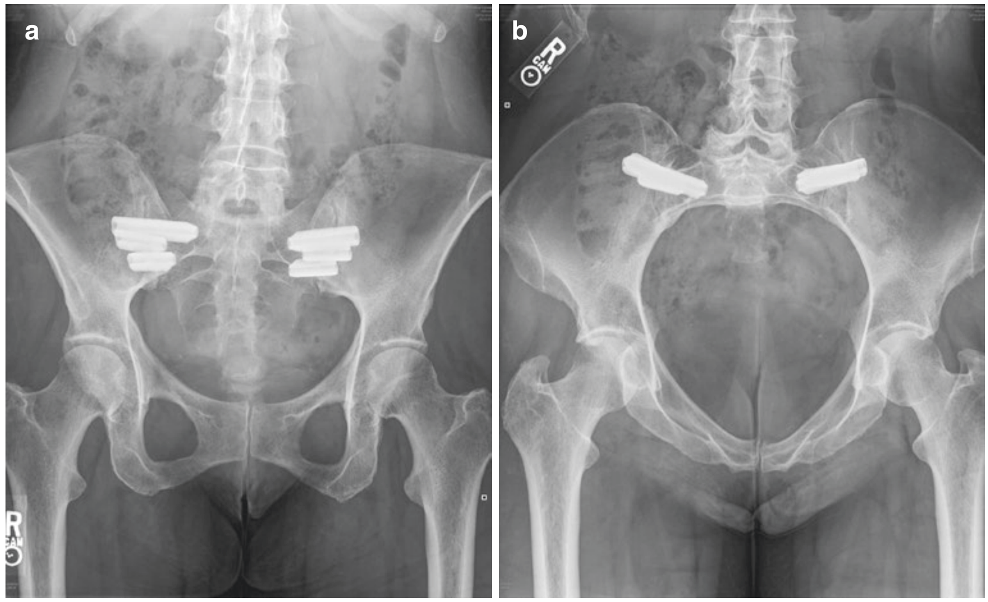

Fig. 44.6 Postoperative anteroposterior (**a**) and inlet (**b**) radiographs following MIS SI joint fusion

erature for this approach reports use of porous triangular titanium implants (iFuse Implant System®, SI-BONE, Inc.). Several prospective randomized multicenter clinical trials using these implants have evaluated clinical outcomes and shown marked improvement in the MIS surgery group across all outcomes measures including VAS, ODI, and SF-36 compared to nonsurgical controls [87–91]. In addition, significant postoperative reduction in utilization of narcotic pain medications has been demonstrated [91]. Numerous retrospective studies have similarly shown not only positive clinical outcomes following MIS SIJF with porous titanium implants, but also durability of results with maintenance of clinical outcomes and fusion rates up to 5 years following surgery [92–101, 103, 104]. Various studies comparing open and MIS SIJF have further substantiated the benefits of the MIS approach, showing less blood loss, reduced operative times and hospital stay, and improved pain levels and clinical outcomes at 1 and 2 years [84, 101–103].

Key Point

- Minimally invasive surgical (MIS) techniques for SI joint fusion have shown improved and sustained outcome measures compared to both long-term nonsurgical management as well as traditional open surgical methods in cases of recalcitrant SI joint pain.

Complications related to MIS SIJ fusion appear to be dramatically lower than those for SI joint fusion, as well as for lumbar spine fusion surgery. Complications typically occur as a result of implant malpositioning, which may either result in new postoperative neuropathic pain or contribute to inadequate long-term fixation leading to pseudoarthrosis and persistent pain. Several prospective trials have shown that a malpositioned implant causing neuropathic symptoms occurs at a rate of 1%, with implant revision resulting in resolution of symptoms in almost all patients [106]. Implant failure may be associated with radiolucency around implants consistent with persistent micromotion concerning for pseudoarthrosis or nonunion [91, 110]. Some alternative screw-based implants do appear to be more susceptible to loosening than triangular titanium implants [105]. Nevertheless, long-term revision rates after SIJF with triangular titanium implants appear to be low [107], especially in comparison to some lumbar spine surgeries [108, 109]. Fusion rates regarding MIS SIJF have not been well reported in the literature, and studies have noted bony bridging across the sacrum at rates of anywhere from 25% to 90%, largely dependent on time from surgery. Even in cases where bony fusion was not well visualized at one-year follow-up, excellent pain and disability and quality of life scores were maintained [91]. Revision rates in these cases were exceedingly rare, and additional studies have shown progression towards arthrodesis by 5 years.

44.8 Summary

SIJ pathology is a common cause of low back pain, and often presents in the setting of degenerative lumbar disease. Accurate diagnosis seems limited by lack of awareness of the condition, as well as the perceived complexity of diagnosis. Several randomized trials have demonstrated that patients with this condition can be diagnosed and treated with high levels of efficacy using multiple endpoint types, though it may necessitate a paradigm shift in recognition of the SI joint as a pain source. Provocative examination of the SIJ, as well as positive responses to image-guided injections are necessary to confirm the SIJ as the pain source. Once SIJ etiology is established, multiple modes of treatment exist. While evidence for nonsurgical treatment is limited, conservative management with physical therapy and/or injections may be effective for many patients. For those who remain symptomatic, minimally invasive SIJ fusion is an effective option in reducing pain and disability and improving quality of life. Currently, strong literature support is available only for porous triangular titanium implants. Procedure success requires careful attention to technical and anatomic factors, including sacral bony and neurovascular anatomy. The likelihood of positive outcomes is increased with careful patient selection and accurate device placement fully across the SIJ.

Summary

- SI joint dysfunction represents a significant component of low back pain, contributing to the etiology of pain in up to 30% of cases.
- Diagnosis of SI joint pain is based on clinical history and provocative SI joint maneuvers during the physical exam, and may not correlate with imaging findings.
- The accepted reference standard for diagnosis of SI joint dysfunction as a source of low back pain is an acute response to image-guided intra-articular SI joint injection.
- The majority of cases of SI joint dysfunction may be successfully managed with conservative modalities.
- For cases of chronic, recalcitrant SI joint pain and dysfunction, MIS SI joint fusion offers superior outcomes measures and response to pain compared to both continued nonsurgical management as well as traditional open SI joint fusion technique.

Quiz Questions

1. In what percentage of low back pain patients does at least a portion of their pain complaints involve the SI joint?
   (a) 1—<2%
   (b) 2—10%
   (c) 3—30%
   (d) 4—>75%
2. What amount of pain reduction is necessary for an image-guided intra-articular SI injection to be considered diagnostic for SI joint pain?
   (a) 1—100%
   (b) 2—75%
   (c) 3—50%
   (d) 4—25%
3. Which of the following is NOT true with regard to traditional open surgical management of SI joint fusion:
   (a) 1—Increased operative time and blood loss compared to MIS surgery
   (b) 2—Increased postoperative hospital stay compared to MIS surgery
   (c) 3—Increased rates of infection compared to MIS surgery
   (d) 4—Improved patient outcome scores compared to MIS surgery
4. Multiple prospective randomized controlled trials have demonstrated which of the following is true with regard to management of chronic SIJ dysfunction?
   (a) 1—Conservative management results in improved patient outcomes compared MIS SIJ fusion at all time points measured
   (b) 2—MIS SIJ fusion has marked improvement in all patient outcomes compared to conservative management at all time points measured
   (c) 3—There is no difference in patient outcomes scores between conservative management and MIS SIJ fusion
   (d) 4—MIS SIJ fusion results in improved patient outcomes compared to conservative management up to 1 year, after which there is no difference in patient performance and functional outcome

Answers

1. c
2. c
3. d
4. b

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