Sacroiliac joint pain: Diagnosis and treatment

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Introduction

Over the last two decades, the sacroiliac joint (SIJ) has increasingly been recognized as an anatomical source of pain that figures in the differential diagnosis of a patient presenting with low back pain (LBP) and/or buttck pain with or without more distant referred pain.\(^1\)-\(^7\) The SIJ is innervated and thus has the potential to be a source of pain.\(^2\)-\(^8\)-\(^13\)

As SIJ pain refers into the buttck and iliac crest near the posterior-superior iliac spine, and also into the groin, abdomen, and leg including the foot,\(^14\),\(^15\) it can be confused with referred pain from other sources, particularly from the lumbar intervertebral disc, lumbar zygapophysial joint (ZJ), hip joint and radicular pain. It is essential that the clinician recognizes these potentially confounding features and takes adequate steps to differentiate between SIJ pain and other pain presentations.

In the early 1900s, the SIJ was thought to be the principal source of LBP,\(^16\) and an important cause of “sciatica”.\(^17\)

Subsequently, and particularly after the discovery of the disc prolapse, it was considered that the lumbar spine and in particular the lumbar intervertebral disc was responsible for most back problems.\(^17\)

Acknowledgement of the SIJ as a source of pain in the ensuing decades commenced in rheumatological literature, but this largely related to seronegative arthropathies, and case reports of various rare infections and tumours.\(^18\),\(^19\)

Subsequently there have been substantial developments in the basic sciences relating to the SIJ, initially and primarily in the osteopathic, physiotherapy, and chiropractic literature,\(^18\),\(^19\) and later in biomechanical and radiological literature.\(^20\)-\(^26\)

The advent of imaging-controlled diagnostic interventions has allowed for a more rational approach to diagnosis, and as a result there is again an increasing awareness that the SIJ is an important cause of LBP and referred pain into the pelvis and leg. It is now estimated that the SIJ may be the cause of 15-38% of all cases of LBP.\(^2\),\(^4\),\(^27\)-\(^30\)

While the SIJ can be a source of pain in various disease states, this article is restricted to mechanical disorders.

Anatomy and biomechanics

The SIJ is the articulation between the triangular sacrum and the two ilia. It is a true diarthrodial synovial joint, and is unlike any other joint in the body. Only the ventral third of the joint is a true synovial joint with a joint capsule and synovial cells;\(^31\) the remainder is composed of three ligaments,\(^32\) the ventral sacroiliac ligament, the intersosseous sacroiliac ligament, and the posterior sacroiliac ligament.\(^33\) From foetal life onward the iliac surface is fibrocartilage and the sacral surface is hyaline cartilage. Subsequent arthrosis of the joint tends to affect the fibrocartilaginous iliac side more than the sacral hyaline cartilage.\(^34\) The dorsal transition between the ligamentous and synovial components shows marked individual variability including osseous clefts, cartilage and subchondral defects, and vascular connective tissue in the bone marrow.\(^31\)

The articular cartilage of the SIJ does not appear to degenerate in a similar manner to other synovial joints in which articular cartilage defects result in bony ankylosis. The SIJ articular cartilage is maintained even in the elderly; it seems that fibrous tissues contribute most to ankylosis so that with aging there is interposition of fibrocartilage-like tissues within the joint (complete fibrous ankylosis).\(^35\) Bony fusion seems to occur only in ankylosing spondylitis.\(^36\) Degenerative changes and intra-articular SIJ ankylosis are substantially more common in men than women.\(^36\)-\(^38\)

The sacrum contains four foraminal pairs on either side, S1 to S4. Each pair has a ventral and dorsal aperture. On xray, the ventral component of the foramen is the most obvious; the smaller dorsal foramen can be difficult to visualize. It is important to recognize this when performing imaging-guided procedures into a sacral foramen. The dorsal component of each foramen may be difficult to visualize on a static image particularly because of the superimposition of the larger ventral component and from bowel gas. However, with the use of CT scan or more preferably a C-arm image intensifier, the dorsal component can be identified. With the C-arm, this is achieved by varying the amount of obliquity and observing that the more superficial dorsal component moves to a greater extent relative to the deeper ventral component (Figure 1).

The synovial part of the joint is more prominent caudally. At the level of the S1 foramen, the ventral 25% of the joint...
is synovial; at S2, the ventral 50% to 75% is synovial and at S3 100% of the SIJ is synovial.\textsuperscript{39}

The pelvis is made up of three bones, with the sacrum positioned as the keystone in an arch from femur to femur (Figure 2). The stability of the sacrum within the pelvis is dependent on: (a) the shape and orientation of the sacrum and its articulations with the ilia, (b) the integrity of the ligamentous structure around the joint, and (c) the extent of muscular compression across the joint.

Variations in the shape and orientation of the sacrum and its articulations are rarely a problem except when these aberrations are quite extreme; for example, after pelvic fractures and in some congenital conditions. The ligamentous function of the SIJ is dependent on intact, stable ligaments and the orientation of the sacrum. The sacrum pivots in a sagittal plane around its true articular joint surface by 6-11°.

Tilting of the superior sacrum in an anterior direction is called sacral nutation. This is its normal position, encouraged by the lumbar lordosis. Excess nutation can occur. Superiorly, such excess nutation is limited directly by the deep interosseous and long dorsal ligaments and indirectly by the ilio-lumbar ligament. Inferiorly, it is limited by the sacroccocygeal and sacrotuberous ligaments.

If all of these ligaments are intact, nutation of the sacrum has the benefit of helping to pull the pelvic ring closed, thus “unlocking” the pelvis and creating a loss of passive compression across the SIJs.

The ligaments and capsule of the SIJ cannot, however, provide adequate compression across the joint surface on their own. The primary compressors of the SIJs are muscular; their actions are termed force closure of the SIJ. Three main muscle groups have been identified: (a) muscles of the pelvic floor, (b) transverse abdomen, and (c) a posterior sling consisting of latissimus dorsi through the thoracolumbar fascia to the contralateral gluteals.\textsuperscript{20,22,40-49}

**Innervation**

Sacroiliac joint innervation is important as the only method for making a diagnosis of SIJ origin pain is anaesthetic block of the joint or its nerve supply, and one possible\textsuperscript{40-49} method of treatment is radiofrequency (RF) treatment directed at target nerves. The SIJ is definitely innervated and it can be a source of pain. The periarticular tissues of the SIJ contain mechanoreceptors and nociceptors.\textsuperscript{2}

Nerve fibres varying from 0.2 micron to 2.5 microns in diameter end in five morphologically different terminals and these terminals are present in the SIJ capsule and adjacent ligaments.\textsuperscript{5} Substance P and calcitonin gene-related peptide (CGRP) immunoreactive nerve fibres have been found in the anterior SIJ capsule and interosseous ligament,\textsuperscript{13} the superficial layer of sacral and iliac cartilage, and the surrounding ligamentous structures.\textsuperscript{12}

Nerves supplying the SIJ are distributed not only to the superficial and deep dorsal sacroiliac ligaments, but also to the sacrotuberous and sacrospinous ligaments; the dorsal rami continue their course laterally, sandwiched between superficial and deep portions of sacroiliac ligaments, and pierce the origin of the gluteus maximus.\textsuperscript{50}

It is considered that the synovial component of the SIJ has a different innervation to the posterior ligamentous component. The synovial joint is likely to be innervated mainly by ventral sources;\textsuperscript{10} its upper ventral portion is innervated mainly by the L5 ventral ramus and the lower ventral portion by the S2 ventral ramus or by branches from the sacral plexus.\textsuperscript{9} The synovial component has minimal innervation by the sacral dorsal rami.\textsuperscript{51}

The dorsal sacroiliac ligaments are innervated by at least the L5 dorsal ramus and lateral branches of the S1-S3 dorsal rami. The L4 medial branch may be involved. The upper dorsal ligamentous structures are innervated by the L5 dorsal ramus; the lower dorsal ligaments by nerves arising from a plexus composed of lateral branches of the dorsal rami of the sacral nerves.\textsuperscript{9} These nerves range from 0.292 mm to 0.997 mm in diameter, and the nerves supplying both the synovial and ligamentous components of the SIJ complex have similar diameters.\textsuperscript{9}

The lateral branches of the sacral dorsal rami emerge from the sacral foramina in a varied array, radiating cephalad, transverse or caudad.\textsuperscript{51} Once they have emerged they do not run in a constant plane,\textsuperscript{11,51,52} but run across the dorsal sacrum either through, superficial to, or deep to the dorsal sacroiliac ligament at a variable depth of up to 1 cm superficial to bone (Figure 3).\textsuperscript{51,53}
Pathophysiology

As noted above, the SIJ is innervated and has the potential to be a source of pain. It can become painful as a result of both intrinsic and extrinsic factors. Intrinsic mechanisms include definitive biomedical processes such as sacroiliitis and tumors. These constitute red flag conditions and are not covered in this article. The other intrinsic mechanism considered to be a risk factor in SIJ origin pain relates to aberration of biomechanical function. The technical terms used to describe these biomechanical features are form closure and force closure. Poor form closure of the SIJ is caused by inefficient bony structure/alignment, absent or stretched SIJ ligaments, or sacral counter nutation. Poor force closure is considered to arise through pain inhibition and poor firing of the compressive muscles (Figure 4). It is likely that long-term lack of force closure across the SIJ can lead to increased strain on the ligamentous structures, which, over time may lengthen and cause further loss of pressure across the joint. Such a joint may then be resistant to muscular retraining.

Extrinsic mechanisms causing loss of form or force closure include trauma (macro or repetitive microtrauma), infection and pregnancy.

Pain in the region of the SIJ is not uncommon after posterior iliac graft harvesting. It occurs in 6-39% in patients who have had iliac grafting for spinal fusion. SJJ pain is also not uncommon after spinal fusion. The prevalence of SJJ pain, diagnosed on the basis of 75% or more pain relief with local anaesthetic block, in one group of patients with significant and chronic LBP post-lumbar fusion surgery was found to be 35%, a figure that seems to be similar to that in other reports.

In a study of long-term outcomes from SJJ radiofrequency neurotomy (RFN), SJJ pain was considered to be idiopathic in 30% of cases, and to derive from motor vehicle accidents in 9%, from a fall or slip in 24%, from overload or a work injury in 26% and from other incidents in 11% of cases.

Clinical presentation and diagnosis

The diagnosis of SIJ pain is predicated on diagnostic anaesthetic injection as clinical and radiological tests have been found to be inaccurate. The most significant feature on clinical assessment of a patient considered to have SIJ origin pain is the site of pain; if the patient points to the posterior superior iliac spine (PSIS) then the pain is more likely to derive from the SIJ. Clinical examination has possible utility when examination findings are considered collectively. Radiological findings are of no particular use other than in the exclusion of some red flag conditions.

The International Association for the Study of Pain (IASP) has proposed three criteria for the diagnosis of SIJ pain. In particular, diagnosis requires that:

- The patient has pain in the region of the SIJ
- The patient’s pain is reproduced by clinical tests that selectively stress the joint, and
- The patient’s pain is completely relieved by selective delivery of local anaesthetic.

Site of pain

In asymptomatic subjects, noxious stimulation of the SIJ evokes pain in the low back, buttock, and upper posterior thigh. In patients with SIJ pain established by fluoroscopically guided SIJ injection, 94% described buttock pain, 72% described lower lumbar pain, 14% described groin pain, 50% described associated lower-extremity pain, 28% described leg pain distal to the knee, and 14% reported foot pain. SIJ pain rarely extends above L5. SIJ origin pain has a similar referral pattern to pain derived from the lumbar spine and from the hip joint, and thus, analysis of pain patterns is not in itself a reliable diagnostic factor.

Type of pain

SIJ pain can present with local PSIS pain and/or somatic referred pain. Local SIJ region pain can be deep and aching,
but it can also be sharp and activated by movement. Somatic referred pain is generally described as diffuse, aching and poorly localized. It is different to typical lumbar radicular pain, which is generally described as long, thin sharp lancing pain that can concentrate distally. Because SIJ referred pain can extend into the leg it can be confused with radicular pain, potentially leading to unnecessary spinal treatment. If the predominant pain is radicular, it is most likely to arise from the lumbar spine due to disc prolapse or canal stenosis. However, it is not impossible for lumbosacral radicular pain to be caused by SIJ pathology. In one series, ventral capsule disruption was present in 70% of patients diagnosed with SIJ pain by intra-articular block. Joint injury, if associated with inflammation, can theoretically be associated with extra-sacral peri-neural inflammation and pain.

It is also important to distinguish neuropathic pain from somatic referred pain. Neuropathic pain typically presents with descriptors such as burning, buzzing and tingling, and has clinical features including allodynia. It can occur in association with somatic referred pain. Although uncommon, lumbo-sacral plexopathy, which is defined as neurological deficit derived from the lumbo-sacral plexus, is more common after sacral fractures than among the entire population of patients with pelvic and acetabular fractures. Thus, it stands to reason that SIJ trauma and pain can be associated with local neural damage, and hence, neuropathic pain.

**Clinical examination**

The validity of physical examination tests is reduced because they tend to stress adjacent soft tissue structures as well as the lumbar spine and hips.

Singular examination tests such as palpation and movement tests are generally considered to be unhelpful in the diagnosis of SIJ pain. However, combined tests may be useful. Synovial SIJ pain can be predicted when three of five pain provocation tests are positive with a sensitivity and specificity of 91% and 78%, respectively, and a consequent likelihood ratio of 4.1. The specificity improves with the absence of centralization of pain. The tests used are:

- The distraction test
- Posterior pelvic pressure provocation (P4)
- Gaenslen’s test
- The compression test, and
- The sacral thrust.

It is unknown whether these tests can predict ligamentous sources of SIJ pain; clinical examination has not been assessed using ligament injection as the criterion standard. These tests individually can be positive in up to 20% of the asymptomatic population.

The SI joint is more likely to be the source of pain if:

a) In identifying the site of pain, the patient points to the posterior superior iliac spine (buttock dimple)
b) Pain is predominantly below the L5 level
c) The sacral sulcus is tender.

Tests for SIJ instability have been proved reliable particularly in the post partum population, but there are no data supporting their efficacy in the management of SIJ pain except in the post-partum population.

Multiple authors raise the concept of SIJ dysfunction, where the self-locking mechanism of the SIJ complex fails due to a loss of form and/or force closure. The tests used to assess SIJ dysfunction are reliable and valid. The presence of SIJ dysfunction is proposed by these authors as a putative cause of SIJ pain. However, although outcome studies on treating this SIJ dysfunction show significant improvements in disability, changes in pain are less impressive. A recent study has, however, shown a compelling pain response in 50% of patients.

**Imaging**

The diagnosis of SIJ origin pain is difficult because there are no valid or reliable correlations between imaging changes and SIJ pain. Imaging therefore cannot be used as a criterion standard for diagnosis or as a basis upon which to assess the validity of treatment. In one study diagnostic CT-guided intra-synovial SIJ injections had a sensitivity of 57.5%, a specificity of 69% and a consequent poor likelihood ratio of 1.9, thus negating the use of CT in a presentation of putative SIJ origin pain except to rule out red flag conditions. Bone scan has a very low sensitivity but a high specificity for SIJ pain diagnosed with diagnostic blocks, and is thus not worth performing. Similarly, plain radiography and MRI cannot reliably detect non-red flag SIJ origin pain.

Changes are often noted on imaging but they are not clinically significant. For example, the CT appearance of the SIJ is closely related to the patient’s age, gender, BMI, and, in women, parity. The widths of the SIJ space and of the subchondral sclerosis on the iliac and sacral sides narrow over time; they were measured to be 2.3+/-0.4 mm, 2.5+/-1.6 mm and 1.4+/-0.5 mm, respectively, in patients younger than 40 years of age and 1.9+/-0.2 mm, 3.6+/-2.1 mm and 2.3+/-1.1 mm, respectively, in patients older than 40 years of age. SIJ changes include increased joint space narrowing and loss of joint space uniformity. Subchondral sclerosis appears to be wider and less uniform in the elderly. Osteophytes are present even in younger patients and their prevalence increases with advancing age. CT has identified six anatomical variants termed accessory joints (19.1% of assessed SIJs), “iliosacral complex” (5.8%), bipartite iliac bony plate (4.1%), crescent-like iliac bony plate (3.7%), semicircular defects at the sacral or iliac side (3%), and ossification centres (0.6%).

**Diagnostic injections**

Properly conducted SIJ injection is considered the criterion standard diagnostic technique. There are a number of intricacies and subtleties in this diagnostic approach to SIJ pain that need to be understood. Diagnostic injections can be performed using various forms of imaging guidance such as C-arm fluoroscopy, ultrasound and CT. More recently, image fusion, in which a software technology matching real-time ultrasonography and a previously obtained CT,
has been tested and found to be accurate, but it is slow, taking on average about 20 minutes.\textsuperscript{99} MR-guided sacroiliac and other spinal injections can also be performed in open high-field MRI using fast TSE sequence designs.\textsuperscript{98} However, although there was a reported accuracy of drug delivery of 100% for nerve root injections, the accuracy for ZJ and SIJ delivery was only 87%, and the average time taken was 29 minutes (range 19-67 minutes).\textsuperscript{99}

Site of injection

There are two components to the SIJ and thus it appears that SIJ pain can be established as the likely source of pain only if both components are assessed. The need to assess both components, however, should be predicated on the treatment that might ensue from such a diagnostic approach. As discussed earlier, the ligamentous component of the joint is innervated by at least the dorsal ramus of L5, and certainly by the lateral branches of the dorsal rami that emerge from the S1, S2, and S3 foraminae. If the treatment is to be RFN of these nerves, then it stands to reason that the diagnostic injection should be directed at these nerves. As the synovial SIJ is innervated ventrally, nerve blocks cannot be used as a diagnostic test for synovial SIJ pain; lateral branch blocks do not anaesthetize the synovial SIJ.\textsuperscript{51} The only method that can be used to diagnose synovial SIJ pain is intra-articular injection. This might be used as a test if steroid or other material is to be injected into the synovial component, or if a surgical procedure such as SIJ is considered relevant.

As the sacral lateral branches run at a variable depth and have a variable course over the sacrum, it is recommended that these nerves be blocked using multi-site, multi-depth sacral lateral branch blocks, as this method renders the interosseous and dorsal sacral ligaments insensate in 70% of subjects.\textsuperscript{51,53} Another option to lateral branch blocks is to inject into the ligamentous component of the SIJ itself using contrast to exclude extraneous injection.

Number of injections

Are controlled blocks required? In high prevalence conditions, such as in the search for ZJ pain in a population of post-whiplash neck pain patients, it has been established that double-blocks are required, one with a short-acting anaesthetic and another with a longer-acting anaesthetic.\textsuperscript{100,101} As the prevalence of an index cohort decreases within a tested population, the chances of false-positive findings with single-blocks rises substantially. In such circumstances, triple-blocks may be necessary, with the addition of a placebo arm. The use of a control block is recommended by Hansen, et al., as their review of two studies with 54\textsuperscript{102} and 120\textsuperscript{103} patients found a false-positive rate for the technique of 20-22% for a single block.\textsuperscript{102} On the other hand, Mitchell, et al. assessed 1146 consecutive double-block technique combined intra-articular and ligamentous injections over a 2.5-year period and found that the first block predicted the control block result in 85% of cases for a positive block and in 87% for a negative block.\textsuperscript{105}

The use of contrast

Contrast is required in all instances, as it confirms that the injectate is in the joint or ligament or adjacent to the nerve, and it excludes intra-vascular injection or extravasation into surrounding tissues. Ventral extravasation has been reported in as many as 61% of all SIJ injections;\textsuperscript{3} if so, false positive blocks occur due to the close proximity of sheaths of the adjacent nerve trunks or roots, including the lumbosacral trunk and the L5 and S1 nerve roots.\textsuperscript{80} Thus, when local anaesthetic is injected into the SIJ, a possible short-term complication is leg weakness for the duration of the local anaesthetic action. Any injection into the SIJ without contrast, even under CT, should be viewed with scepticism at least in respect of its diagnostic utility.

Volume

In intra-articular SIJ injection the accepted maximum volume is 2.5 ml,\textsuperscript{51} but less should be injected if there is increased pain or pressure. Ligamentous injection volume is about 2 ml. The multi-site multi-depth injections onto the lateral branches of the dorsal rami from S1 to S3 require 0.2 ml per infiltration.\textsuperscript{31}

Interpretation

In research, it is generally considered that the criterion for a positive block should be 100% pain relief or very close to it. In clinical practice, reduction of VAS in the order of 80% may be considered a positive finding.\textsuperscript{16}

Summary

Pain from either or both components of the SIJ can be suspected when the presenting pain concentrates over the SIJ. A combination of physical tests may predict a positive diagnostic block regime. Imaging tests are unhelpful in diagnosing such pain, but when indicated may be helpful in excluding red flag conditions. Controlled blocks are used as the criterion standard for diagnosis.

Treatment

A number of modalities are available for the treatment of putative SIJ pain. At present, however, the literature regarding the efficacy of each is limited.

By the time a target-specific diagnosis is made by injection, it is likely that the patient will have failed numerous trials of conservative management including physical therapy, medications, bracing, kinesiology and exercise, and it is assumed this includes targeting specific retraining of the pelvic floor, transverse abdominus and the posterior sling. The diagnostic injection into the joint or the dorsal interosseous ligament typically includes cortisone and may thus be therapeutic in itself. If it is not, percutaneous radiofrequency neurotomy (RFN) can be considered. Stabilization of the joint through prolotherapy or fusion may also be appropriate.
Efficacy

Corticosteroid injection

Sacroiliac corticosteroid injections have not been tested with randomized controlled trials (RCTs). Accordingly, a systematic review concluded that the evidence supporting therapeutic injection is limited.\(^\text{104}\) However, many case series studies report that intra-synovial SIJ corticosteroid injections provide good to excellent pain relief with a duration of up to 10 months.\(^\text{32}\)

A retrospective practice audit of 155 patients who underwent diagnostic and therapeutic fluoroscopically guided contrast confirmed SIJ injections with local anaesthetic and corticosteroid were considered positive if they produced 50% or greater pain relief during the local anaesthetic block phase and if there was two weeks or more subsequent pain relief. Of the 155 patients, 69 (45%) had had previous lumbar surgery and 120 (77%) were positive responders over a mean duration follow-up period of 44 months (range 26-101 months).\(^\text{106}\) The positive responders received a mean of 2.7 injections per patient; 40 required one injection only, 29 required two, 22 required three, and 27 required four or more. The mean duration of response for those receiving more than one injection was 9.3 months per injection (range 1-58 months). There were no adverse events.

In practice, corticosteroid and other injections can be inserted into either or both the synovial or ligamentous component of the SIJ. Intra-synovial etanercept is now injected in the treatment of ankylosing spondylitis. A case series reported that it improved both clinical features and morphological parameters significantly, and that it was safe and cost-effective.\(^\text{107}\)

Radiofrequency neurotomy

Sacroiliac treatment using cooled RFN has been assessed positively with a RCT.\(^\text{108,109}\) In this trial, 28 patients were equally divided into treatment with cooled RFN and sham treatment groups. Patients in the treatment group received denervation of the L4 medial branch, the L5 dorsal ramus and at the S1-S3 lateral branches. The proportion of participants experiencing greater than 50% pain relief at one, three, and six months postoperatively in the treatment cohort was 79%, 64%, and 57%, respectively; in the placebo group, the proportion of participants experiencing greater than 50% pain relief at one and three months postoperatively was 14% and 0%, respectively. Subsequently, 11 patients crossed over to RFN treatment, and of these, at one, three, and six months the proportion of patients reporting improvement was 64%, 55%, and 36%, respectively. The treatment effect was seen to diminish by 12 months; at that time only 14% (two patients) of the treatment group had persistent pain relief. It was suggested that larger studies were needed to further assess the efficacy of SIJ RFN.

The same group reported on 77 patients who underwent lateral branch SIJ RFN treatment using a 50% reduction in pain at six months as a successful outcome. Of these, 40 (52%) obtained a positive outcome. The multivariate analysis found that predictors of an unsuccessful outcome were age older than 65 years and pain radiating below the knee. They also noted that cooled, rather than conventional RFN, was associated with a higher percentage of positive outcomes and that no single clinical variable reliably predicted treatment results.\(^\text{110}\)

Previous case series had indicated that SIJ RFN may have a role to play in the treatment of SIJ pain. The first main paper describing SIJ RFN used a stereotactic technique. After displaying the anatomy of the lateral branches of the sacral dorsal rami, Yin, et al. reported in a retrospective audit that 64% of 14 patients treated with SIJ RFN reported successful outcome for at least six months, with 36% achieving total relief.\(^\text{111}\) Kapural, et al. performed a retrospective chart review on their initial cases using the cooled RFN technique; short-term efficacy was apparent as 18 out of 26 cases were good at three months.\(^\text{112}\) They also performed a safety audit on the first 100 cases. There were no significant complications other than short term (less than six weeks) pain exacerbation four cases, and in two cases there was an area of cutaneous numbness over the buttocks.\(^\text{112}\)

Mitchell, et al. performed a prospective consecutive case series on 82 cases using a traditional RFN method directed at the L4 medial branch, the L5 dorsal ramus and the S1-S3 lateral branches.\(^\text{11}\) The cases were divided equally into 5-7 months and 8-13 months follow-up. Greater than 50% pain relief was achieved in 22% of patients in the 5-7 months group and 42% of patients in the 8-13 months group. Patient satisfaction was 58% versus 63% in the respective groups. At eight months, the average reduction in VAS was 33%, with the 42% of patients with greater than 50% relief reporting an average reduction of 74% in VAS.\(^\text{105}\)

Outcomes from treating the SIJ complex with traditional RF needles are dependent to some degree on the cause of the original injury; patients able to identify the cause of their injury (whether it be from a motor vehicle accident, fall, overload/work injury, etc.) are more likely to report excellent pain relief following RFN than those unable to pinpoint the mode of injury.\(^\text{72}\)

While sacral RFN is a safe procedure, there has been a case report of a permanent L5 sensory radiculopathy following a bilateral L3 to L5 RFN.\(^\text{113}\) However, such a complication should arise only from inaccurate positioning of the needle.

Prolotherapy

Prolotherapy for LBP including SIJ region pain and tenderness appears to be no better than placebo. In a RCT, Yelland, et al. tested patients with LBP that might have included putative SIJ pain with injection onto any local tender structure either with a combination of 20% glucose and 0.2% lidocaine or with saline.\(^\text{114}\) The outcome was that prolotherapy was equally effective as placebo but that both seemed to be somewhat effective in that in 46% of cases there was a 50% pain reduction and 42% of cases there was a 50% reduction in Roland-Morris disability index.

In a descriptive prospective trial case series study, Cusi, et al. examined functional outcome measures and improvements in load transfer on clinical examination but not pain after CT-guided injections of 50% glucose on...
three occasions six weeks apart. \textsuperscript{91} Functional improvement occurred in 76% of patients at 3 and 12 months follow up and in 32% at 24 months follow up.

In a small case series of prolotherapy on the ligaments of the SIJ, Mitchell, et al. found 86% patient satisfaction, with 50% of patients having an average reduction of pain of 64%. 64% of patients reported feeling stronger. \textsuperscript{34} In a much larger cohort (N=77) with longer-term follow-up, as yet unpublished data showed 71% of patients felt stronger, 38% of patients had less than 75% pain relief with a further 22% having less than 50% pain relief. Interestingly, pain relief was highly correlated with improvements in stability. 76% of patients were satisfied.

**Surgery**

Surgery with SIJ arthrodesis (via a modified Smith-Petersen technique) for putative SIJ pain, diagnosed by pain relief with intra-articular joint injections under fluoroscopic guidance, has been studied and found in one series to be reasonably successful in terms of physical functioning, role physical, bodily pain, vitality, social functioning, role emotional, and neurogenic and pain indices. \textsuperscript{115}

A case series on 15 consecutive patients treated with percutaneous SIJ fusion using hollow modular anchorage screws filled with demineralized bone matrix after diagnosis with a single SIJ injection of local anaesthetic and steroid under image intensifier control reported that at a mean follow-up of 17 months there was a significant improvement in disability, physical function, and pain; of the 15, 13 reported good to excellent improvement. \textsuperscript{116}

However, a more sobering picture emerges from a retrospective study on 17 patients who underwent bilateral SIJ fusion with internal fixation and decortication of the SIJ after diagnosis via local anaesthetic joint infiltration, temporary external fixation or bone scan as at an average follow-up period of 39 months only three patients (18%) reported moderate or absent pain. The rest had either marked or severe pain. \textsuperscript{117}

Another much less invasive technique, SIJ debridement, was retrospectively studied on 38 patients with SIJ pain diagnosed with SIJ injection. At a follow-up period of two years 61% had 50% or more reduction in pain and 53% had 75% or more reduction in pain. \textsuperscript{118}

Additionally, percutaneous, CT-guided stabilization from S1 to S2 has been reported to be a potentially acceptable treatment for recalcitrant SIJ pain. \textsuperscript{119}

**Neuromodulation**

Neuromodulation with spinal cord stimulation, peripheral nerve stimulation, or sacral nerve stimulation can potentially relieve persistent pain from the SIJ that is recalcitrant to other therapies.

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