Instructional Lecture: Spine

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A painful unknown: sacroiliac joint diagnosis and treatment

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- The sacroiliac joint (SIJ) is a complex anatomical structure located near the centre of gravity of the body.
- Micro-traumatic SIJ disorders are very difficult to diagnose and require a complete clinical and radiological examination.
- To diagnose micro-trauma SIJ pain it is recommended to have at least three positive provocative specific manoeuvres and then a radiologically controlled infiltration test.
- Conservative treatment combining physiotherapy and steroid injections is the most common therapy but has a low level of efficiency. SIJ thermolysis is the most efficient non-invasive therapy.
- SIJ fusion using a percutaneous technique is a solution that has yet to be confirmed on a large cohort of patients resistant to other therapies.

Keywords: diagnosis; dysfunction; micro-traumatic pains; minimally invasive fusion surgery; sacro-iliac joint (SIJ)

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Introduction

The sacro-iliac joint (SIJ) is a strong load-bearing joint that forms part of the pelvic ring with a very low range of motion that varies during life. Its implication in low back pain was not well established before the development of modern imagery including magnetic resonance imaging (MRI) and single photon emission computed tomography (SPECT-CT). Accordingly, the the SIJ is well-recognized as a generator of axial low back pain. Without evidence of aetiology, its pathology has become more and more studied since the 1990s. It is now accepted that SIJ dysfunction is really difficult to diagnose due to the symptomatology which is sometimes closely similar to other lumbar spine pathologies (lumbar degenerative disc diseases or facet arthropathy and hip injuries). It is recommended to be very cautious before diagnosing a SIJ dysfunction and to exclude other spine pathologies using a wide range of clinical and radiological studies before treatment.[1] The main objective of this article is to summarize knowledge of SIJ dysfunction due to micro-traumatic lesions excluding inflammatory diseases, infections and tumours and to give some recommendations for treatment options including conservative treatment and surgical fusion techniques focussed on minimally invasive surgery.

Anatomy of the SIJ

In 2012, Vleeming et al published a complete overview of the SIJ anatomy and functions.[2] The sacro-iliac joint is a C-shaped joint placed between the auricular surface of the sacrum and the ilium (Fig. 1). It is involved in the transfer of load and motion from spine to lower limbs and is essential for absorbing mechanical and torsional stresses to the pelvic region (repeated or traumatic injury). The peculiarity of the SIJ comes from the fact that it is covered by two different types of cartilage: the sacral surface is covered by hyaline cartilage and the iliac surface by fibrocartilage. The cartilage layer is thinner in the ilium (0.5 mm) than in the sacrum (3 mm).[3] The iliac surface is localized at the internal part of the ilium, above the greater sciatic notch. The sacral part is located in the upper lateral sacrum. Articular surfaces are not flat, they are covered with ledges and pits. The surfaces fit with each other, but the line spacing is variable according to a top or bottom view from the upper aspect.

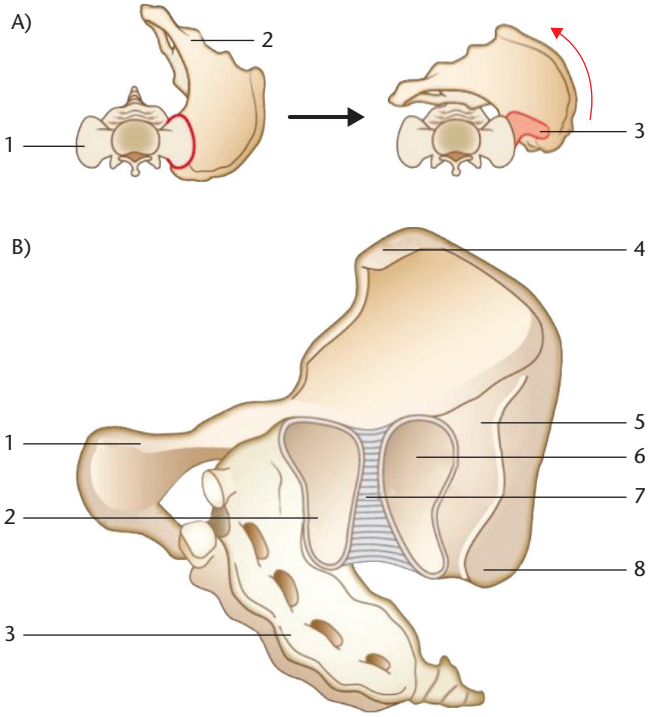

Fig. 1 Anatomy of the SIJ. (A) Top view of the pelvic region. Sacro-iliac joint (SIJ – red line) is located between the sacrum (1) and iliac crest (2). A slight spread between the iliac crest and the sacrum allows a superior view of the SIJ region (3). (B) Transverse view of the pelvic region. The Iliac crest is spread from the sacrum to properly describe the anatomy of the pelvic region and observe the SIJ plate: (1) body of the pelvic bone, (2) auricular surface of the sacrum, (3) sacrum, (4) antero-superior iliac spine, (5) iliac tuberosity, (6) auricular surface of the ilium, (7) anterior sacro-iliac ligament, (8) postero-superior iliac spine.

The SIJ is supported and re-enforced by several complex sacral ligamentous structures (Fig. 2) summarized below:

- A very dense and short fibrous capsule encloses the joint which is re-enforced by powerful ligamentous structures. The anterior sacro-iliac ligament, composed of two bundles (cranial and caudal), is located below and in front of the joint. The cranial bundle limits the lowering of the promontory and the caudal bundle limits the rise of the coccyx during movement or ventral rotation of the sacrum.
- The inter-osseous sacro-iliac ligament, which is a very strong structure, is positioned immediately above the back of the joint on the sacrum and the ilium.
- The dorsal sacro-iliac ligament is oriented so that the joint is blocked when it is put in tension. It can be described as a superficial plane which consists of four bundles.
- The ilio-lumbar ligament is composed of two bundles, cranial and caudal which also lock the joint.

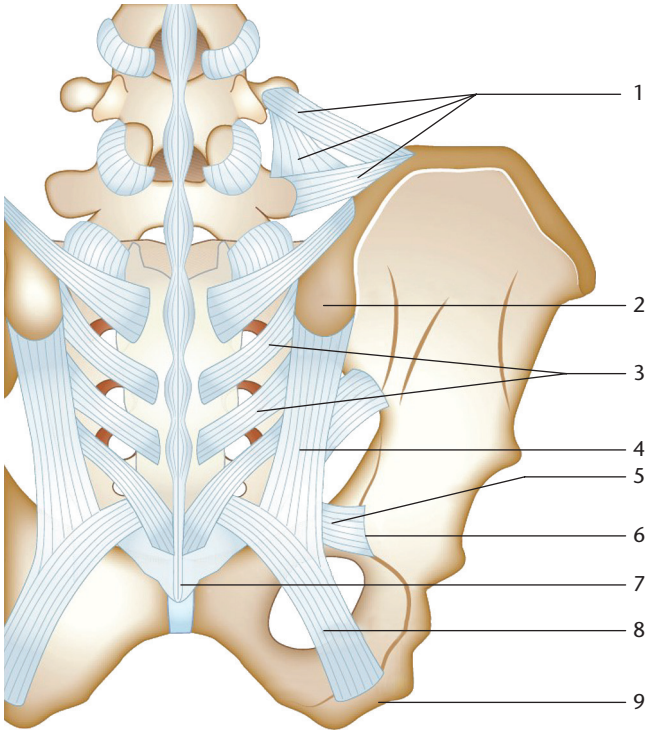

Fig. 2 Posterior ligaments of the sacro-iliac joint (posterior view). (1) Ilio-lumbar ligaments, (2) postero-superior iliac spine, (3) Inter-osseous sacro-iliac ligaments, (4) posterior sacro-iliac ligaments, (5) sacro-spinous ligament, (6) ischial spine, (7) coccyx; (8) sacro-tuberous ligament, (9) ischial tuberosity.

At a distance from this very powerful ligamentous structure, there are two accessory ligaments: the sacro-tuberous ligament and the sacro-spinous ligament, which both have no essential role in the stabilization of the sacro-iliac joint. Their section in pudendal nerve release surgery does not produce a significant increase in sacro-iliac joint pain. The muscles also contribute to the stability of this junctional structure. The latissimus dorsi via the thoraco-lumbar fascia, gluteus maximus and piriformis are the three active muscles which re-enforce the structure.

Innervation of the sacro-iliac joint has become an important topic for investigation to try to understand and explain SIJ pain. In 1957, Solonen was one of the first to describe the branches of the lumbosacral plexus from the superior gluteal nerve, the dorsal ramus of the first two sacral nerves (S1, S2) and the obturator nerve.[4] In 1966, Nakagawa completed this description by describing nerve filaments from the anterior branches of the L4 and L5 roots, the superior gluteal nerve, and the dorsal branches of the L5, S1, S2 roots.[5] The distribution of the innervation in the capsule is according to the root distribution. Grob et al primarily attribute innervation to the dorsal sacral branches. They base this on foetal dissections showing that all the nervous filaments come from the dorsal

mesenchyme.[6] This hypothesis has been re-enforced by the work of Fortin et al.[7] However, the existence of anterior innervation of the capsule is now recognized.[8]

Biomechanics

The mobility of the SIJ is very small and usually not very noticeable. However, several conditions can lead to a sacro-iliac mechanical dysfunction associated with an imbalance of effective transfer of loads and consequent SIJ pain (pregnancy, SIJ infection, ankylosing spondylitis, and traumatic fractures are examples). In 1990, Vleeming et al adapted the concept of 'form/force closure' to the SIJ which described the dynamics and mechanical aspects of the joint.[9,10]

According to the complex organization of the ligaments and muscles around the pelvic area, the SIJ can describe movements in the three anatomical planes with angular, linear and symmetrical displacements or not. We can thus describe a movement of nutation and counter-nutation (Fig. 3). The nutation corresponds to the posterior displacement of the distal end of the sacrum during the displacement of the sacred hollow rail on the coxal solid rail. This movement is favoured by the flexion of the hips. Counter-nutation, on the other hand, is the advancement of the distal end of the sacrum, favoured by the extension of the hips. The angular value of the displacement goes from 0° to 12°.

In the bipodal frontal plane, the weight of the body, which is applied to the sacrum, is considered to be halved. Each half is distributed at the level of sacro-iliacs, then to the femoral heads. The weight of the body tends to push the sacrum downwards, which leads to an automatic locking effect.

Diagnosis of sacro-iliac micro-traumatic pain

After elimination of inflammatory diseases, ankylosing spondylitis, infections and tumours by clinical, laboratory tests and imaging, there are still patients with SIJ pain with normal-looking X-rays. The majority of these patients with a SIJ dysfunction described the presence of pains arising in the area of the L5-S1 nerve distribution which is closely similar to other causes of low back pain. Then, it is mandatory to exclude other causes of pain, for example, lumbar inter-vertebral disc diseases, lumbar posterior facet joint pain, hip pain, muscular pain (piriformis syndrome), osteoporotic fracture of the sacrum. However, due to the lack of specificity, the SIJ dysfunction cannot be diagnosed using a single clinical evaluation of pain.

For micro-traumatic pain from the SIJ, it is largely recommended to obtain the diagnosis based on the use of provocative manoeuvres summarized below:

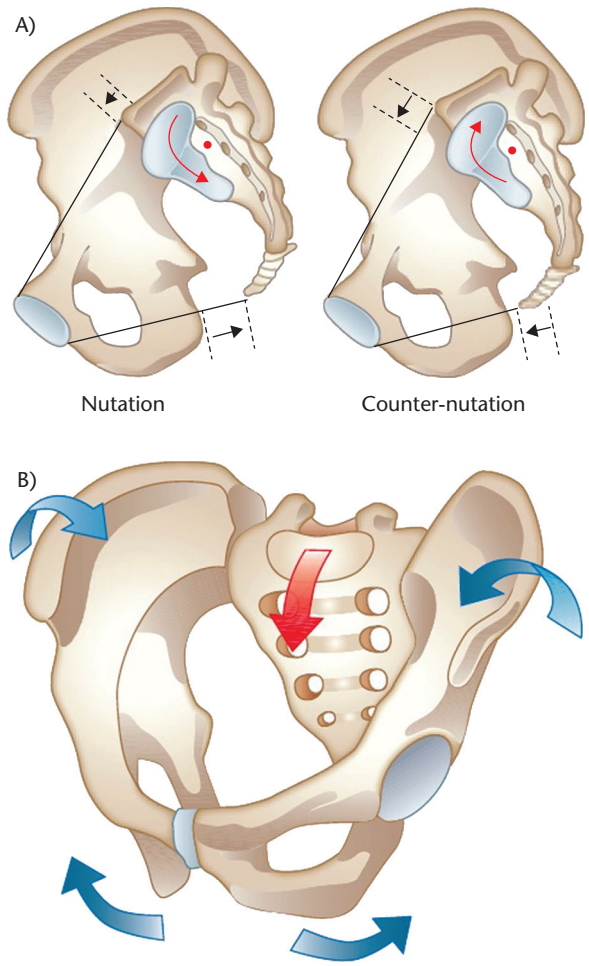

Fig. 3 Mobility of the sacro-iliac joint. (A) Inter-osseous sacro-iliac ligaments (red points) are considered as the axis of rotation of the sacrum. Two mains movements are permitted depending on the sense of rotation: nutation and counter-nutation (red arrows). In the case of nutation, the coccyx moves away from the pelvis which is responsible for the enlargement of the lower outlet. Counter-nutation is described by the narrowing of the lower outlet and the enlargement of the upper outlet due to the close position of the coccyx to the pelvis. (B) During the nutation movement, the upper plate of S1 moves forward and the iliac crests are getting closer. The ischia move away which is associated with the increasing diameter of the lower outlet.

- Physical examination.
- Östgaard test: patient lying, hip flexed at 90°, knee flexed, the examiner puts a moderate pressure of about 5 kg in the axis of the femur to the ground (Fig. 4A).
- FABER test meaning 'Flexion Abduction External Rotation'; the examiner maintains the iliac crest on the opposite side and gradually drops the contralateral flexed hip (Fig. 4B).
- Compression test involving bringing together the patient's two iliac wings whilst lying on the side (Fig. 4C).

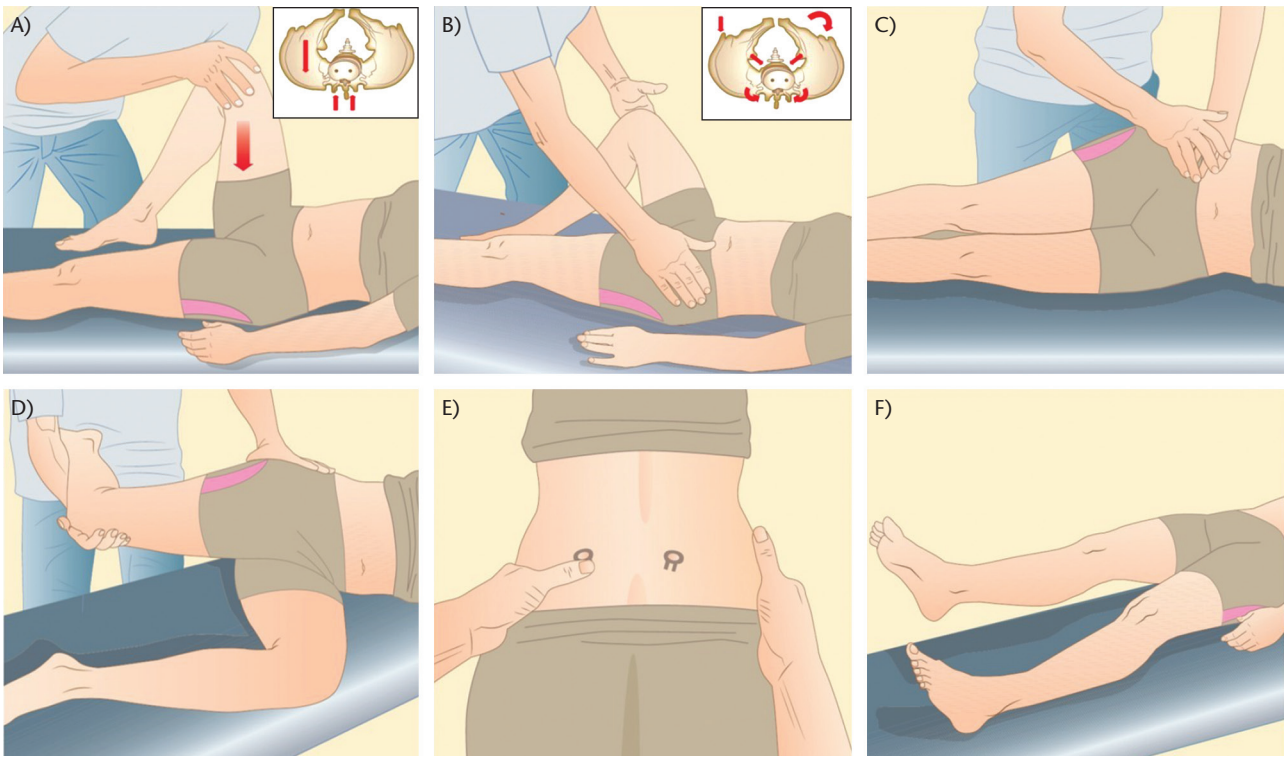

Fig. 4 Provocative manoeuvres to diagnose a sacro-iliac joint (SIJ) dysfunction. If three of five of the following provocative manoeuvres are positives, the clinician can suspect an SIJ dysfunction. The diagnosis has to be confirmed using a radiological test or injection test. (A) Östgaard test. (B) Faber test. (C) Compression test. (D) Gaenslen's test. (E) 'Finger sign' test. (F) Lasègue test.

- Gaenslen's test: with the patient lying on his/her side, the hip is flexed with a straight knee, the examiner performs a hip extension with one hand while holding the iliac wing with the other hand (Fig. 4D).
- The long ligament test, also called the 'finger sign' is positive when producing a pain caused by pressure on the upper part of the SIJ (Fig. 4E).
- The active Lasègue test is a functional test, the patient lying on his back must lift his lower limb with a straight tense knee. This causes pain in the SIJ (Fig. 4F).

If at least three of the five clinical tests are positive, there is a strong suspicion of pain from the sacro-iliac joint. However, the use of provocative manoeuvres alone is controversial due to the large range of false-positive results.

Then it is recommended to confirm the clinical investigations using an infiltrative test. C-arm or CT-scan-guided infiltrations or fluoroscopy-guided intra-articular injections in the lower part of the SIJ with local anaesthetic and corticosteroids offer a dual function of diagnosis and treatment of SIJ dysfunction. According to the International Association for the Study of Pain, the use of a complete clinical evaluation based on the use of both provocative manoeuvres and infiltrations is the minimum criterion for the diagnosis of SIJ dysfunction.

Clinical evaluation can be supported using radiological complementary examinations (X-rays, MRI, CT scans or tomography). CT scan and MRI have no diagnostic value for micro-traumatic pain of the SIJ but they are mandatory to exclude inflammatory disease. Scintigraphy is sometimes positive but has no specificity. Some recent studies show that ultrasound may show an increase in blood flow around the joint but this needs to be confirmed by further studies.[1]

How to treat sacro-iliac micro-traumatic pain?

Physiotherapy

Despite the widespread use of non-operative solutions for treatment of SIJ micro-traumatic pain (physical therapy, manual manipulations or stabilization exercises), there is no clear evidence of the usefulness of physiotherapy. Studies reported in the literature are largely controversial due to heterogeneous approaches used and the lack of real evidence comparing different techniques.[11–13]

In 2005, Nilsson-Wikmar et al reported a study evaluating three different physical treatments in pregnant women with sacro-iliac pain using 'positive' clinical manoeuvres. This study showed no difference between non-elastic belt

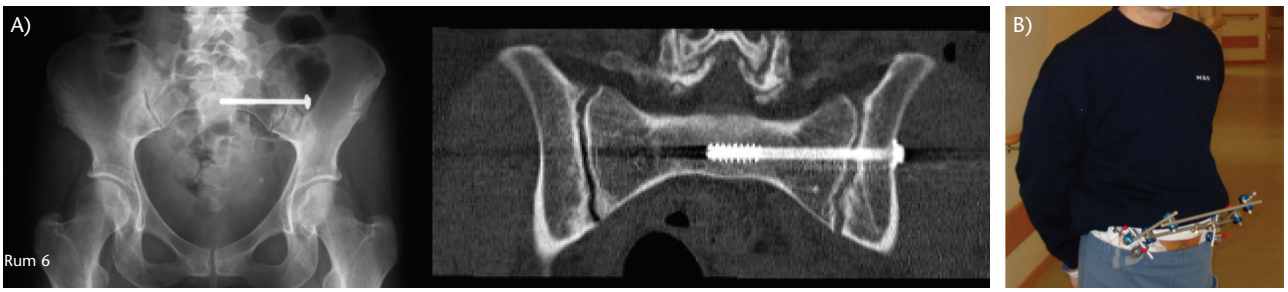

Fig. 5 Previous approaches. (A) Unilateral fusion of the sacro-iliac joint (SIJ): radiograph and computed tomography scan control. (B) External frame for sacro-iliac fusion.

use, daily home exercises, and more structured exercises in a physiotherapy programme. All three groups showed improvement between the 38th week of pregnancy and the 12th month after delivery. The conclusion of their article is in favour of the lack of demonstrated effectiveness.[14] Similarly Stuge et al tried to evaluate the indications for this conservative treatment without reaching a definite conclusion.[15,16] Authors insist on a physiotherapy treatment adapted for each patient which confirms the absence of any defined protocol.

Many publications report manual therapies by osteopathy or chiropractic to treat sacroiliac pain. However, these studies used different techniques and their protocols were not clearly defined to confirm the success achieved. A single well-performed study did not show an improvement in sacroiliac pain after manipulation treatment.[17] Even if positive results are found from physiotherapy, authors largely debate the cost-consequences of the treatment employed. Patients with SIJ micro-traumatic dysfunction require several physiotherapy sessions over a long-term follow-up, which is costly.

Steroid injections

Intra-articular injection of anaesthetics is the standard for diagnosis and treatment of SIJ micro-traumatic pains. Caution should be taken regarding the use of SIJ block due to the high rate of false-positive results described by various authors. A literature review by Kennedy et al found that clinical trials performed with dual injection of local anaesthetics and steroids have a false-positive rate response of more than 20%. It is otherwise concluded that this therapeutic combination gives better results with 75% pain relief for more than 35% patients.[18] It is also found that the efficacy of intra-articular steroid injection in the SIJ has limitations. Authors described a positive response within a few minutes after injections, lasting several months. Luukkainen et al conducted two prospective randomized studies showing reduction of pain with steroid injections compared with a control group, but the difference was not confirmed at one and two months.[19] In this case, it is assumed that the effect of steroid injections is not long lasting. According to the work of Hawkins and Schofferman, a mean of 2.7 injections per patient is required to produce positive pain relief with a mean response duration of 9.3 months.[20] The need for frequent injections on a long-term basis should be considered carefully for a complete cost-efficacy evaluation compared with other treatments such as durable SIJ fusion surgery.

Surgery

The first report of arthrodesis of the SIJ for micro-traumatic pain was in 1987 by Waisbrod et al.[21] They described a direct posterior approach of the joint, a removal of cartilage surface and bone grafting from the iliac crest. No metallic device was used. The result of this technique was only 50% of patients showing improvement. In 2005, Buchowski et al reprorted 20 cases operated on with his technique consisting of a posterior approach of the SIJ, a reflexion of a gluteus maximus flap, a complete resection of the joint and a fixation with a plate running all along of the SIJ.[22] This technique also showed show an improvement in approximately 50% of the patients. In 2006, Schütz and Grob described a technique for bilateral fusion of the SIJ. This technique consisted of bilateral incisions made over the posterior iliac crests extending 10–15 cm anteriorly to the posterior superior iliac spine (Fig. 5A).[23]

The opposite ilium was then perforated until the tip of the threaded rod appeared on the lateral side. Triangular buttress plates were put in place and a second rod was inserted parallel to the first rod. Through the remaining hole a cancellous bone screw was placed as a lag screw fixing the sacrum between the two iliac bones. Bone graft from the iliac crest was then impacted into the sacro-iliac joint. He reported a bad outcome for this technique with more than 80% of patients unsatisfied.

In 1999, Sturesson et al published the results of 10 cases of sacro-iliac fixation with an external frame (Fig. 5B). The external frame was anchored to the two iliac crests. Their radiological study shows a reduction of mobility in the SIJ. They suggested the use of this frame as a diagnostic tool in SIJ pain.[24]

Recently, new techniques using small titanium implants and a minimally invasive approach have been described. In 2016, Duhon et al published a multi-centre prospective

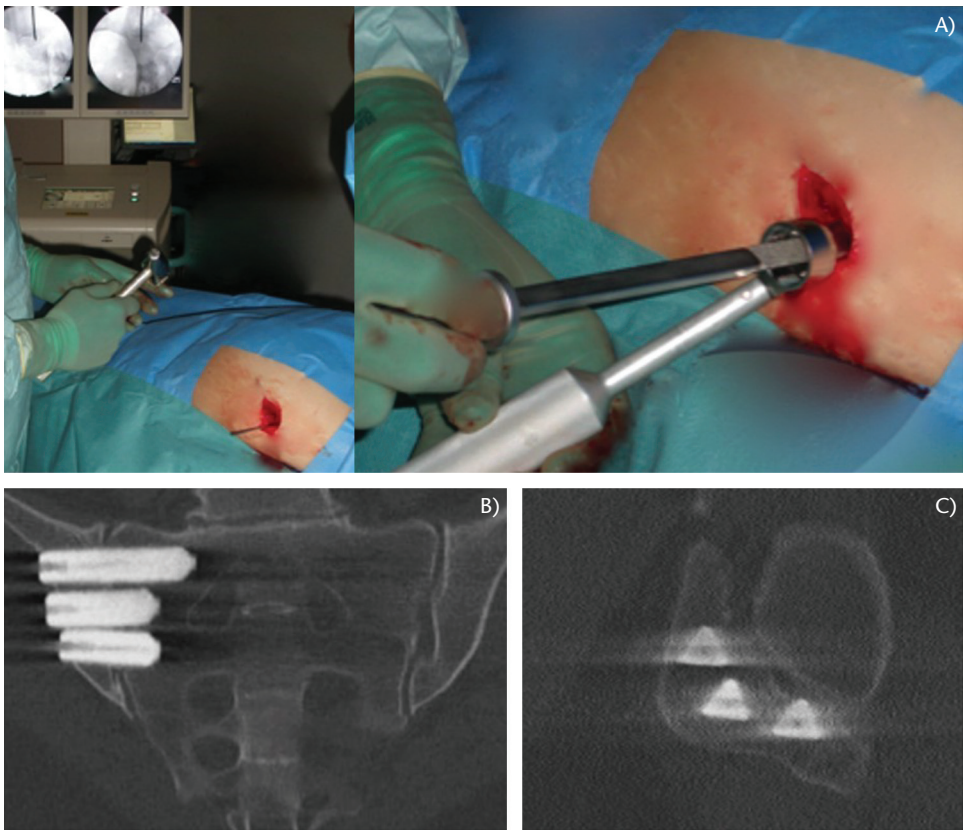

Fig. 6 Minimally invasive surgery of the sacro-iliac joint (SIJ). (A) Patient is in the ventral position. C-arm-guided approach allows for precisely inserting the first guide pin and to measure the screw length. The guide is perpendicular to the plane of instability through the ilium and the sacrum. A larger guide pin allows the insertion of the screws. SIJ fusion can be obtained using three triangular screws. The good position of each screw has to be post-operatively confirmed by computed tomography scan (B and C).

study using these techniques.[25] Under general anaesthesia, patients were placed in the prone position on a radiolucent table. A 3 cm to 5 cm lateral buttock incision was made, and dissection was carried down to the gluteal fascia to reach the outer table of the ilium. A guide pin was inserted through the ilium across the SI joint into the body of the sacrum, avoiding the sacral neural foramen. Pin placement was confirmed with lateral, inlet, and outlet fluoroscopic views of the pelvis. A soft tissue protector was passed over the pin, followed by use of a drill to create a pathway through the ilium and into the sacrum, and to decorticate the articular surfaces of the joint. A triangular broach was then used to further decorticate the joint and prepare the pathway for placement of the implant (Fig. 6), which was driven into place. Using a parallel drill guide, additional implants (usually a total of three) were placed across the SIJ. Typically, the most cephalad implant was placed within the sacral ala above the S1 foramen, the second implant was positioned above or adjacent to the S1 foramen, and the third implant was positioned between the S1 and S2 foramen. The wound was irrigated and the tissue layers closed in a standard fashion. Subjects requiring treatment of both SI joints could undergo either bilateral same-day surgery or staged surgery. This technique showed a high rate of satisfaction (around 90% of patients satisfied).

In 2017, Rappoport et al presented a modified minimally invasive technique using hydroxyapatite-coated screws instead of titanium implants.[26] An incision of 2 or 3 cm was made 1 cm distal to the intersection of the lines with blunt finger dissection to the fascia. The first guide pin was inserted under fluoroscopic guidance in all three planes across the joint, staying caudal to the alar line and within the sacrum, beginning near the posterior sacrum and angling approximately 10° to 15° downwards. An outlet view of pin depth allowed measurement of screw length. The joint was drilled to prepare for screw insertion, and the screw slot packed with autogenous bone graft collected from drill reamings. The screw was then inserted over the guide pin (Fig. 6A). A switch to inlet view and use of the dual parallel pin guide were followed by insertion of the second guide pin into the bone. The lateral view was

used to check the first screw position, and the second guide pin was advanced while staying lateral to the S1 foramen on outlet view. While remaining with that view, screw length was measured, and the screw was drilled, packed, and implanted in a similar way to the first screw. These steps were repeated for the third screw. Positioning was checked on final inlet, outlet, and lateral views. All reconstructions included three screws (Figs 6B and 6C). Results were positive with a satisfaction rate of 86% at one-year follow-up.

Based on these recent findings, a minimally invasive approach is now recommended for patients with SIJ micro-traumatic pains compared with other approaches. The clinical study by Polly et al confirms this hypothesis with a greater rate of improvement of pain for patients treated with minimally invasive fusion surgery compared with patients managed via non-surgical therapy or conservative treatment.[27–29] These studies were supported by a cost-efficacy evaluation of SIJ fusion vs. non-surgical therapy. In that sense, two economic studies of cost-effectiveness revealed that SIJ fusion is a long-term cost-effective strategy compared to traditional non-surgical treatments.[30,31]

Conclusions

The SIJ is a hinge joint between the spine and lower limbs. Its mobility is very low but increases during pregnancy and post partum. Micro-traumata are responsible for chronic pains that must be differentiated from hip and spine pain. The diagnosis is mainly based on clinical evaluation and specific tests associated with the infiltration of local anaesthetic. The conservative treatment combining physiotherapy and stretching aims above all to ensure the muscular re-enforcement of the latissimus dorsi, glutei and hamstrings. The thermolysis of the posterior sensory branches has shown a certain efficiency which may fade over time. Resistant cases can now benefit from minimally invasive arthrodesis with a reported good success rate. A minimally invasive fusion approach to treat SIJ micro-traumatic pains should be considered regarding the high rate of pain relief and duration response. Generalization of this surgical solution for patients with SIJ micro-traumatic pain needs more consideration and evaluation with regard to patient comorbidity, medical conditions and long-term follow-up.

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