SACROILIAC JOINT DYSFUNCTION: BIOMECHANICS, CAUSES AND CLINICAL PICTURE

Tarek Elhewala[1], Amr Mohamed El-Adawy[2], Akram Abduallah Ahmed Alfaghi[3*], and Mohammed Hassan Abd Ellatif[4]

Article History: **Received: 22.06.2023** **Revised: 04.07.2023** **Accepted: 22.07.2023**

Abstract:
Low back pain persisting or appearing after a technically successful lumbar fusion challenges clinicians. In this context, the sacroiliac joint could be a possible source of pain, but the frequency of its responsibility is not really known.

Keywords: Sacroiliac Joint, Pain, Spinal Fusion Surgery

[1,2,4]Orthopedic Surgery Department, Faculty of Medicine, Zagazig University
[3*]Orthopedic Surgery Department, Faculty of Medicine, Gharian University- Libya

***Corresponding Author:** Akram Abduallah Ahmed Alfaghi
*Orthopedic Surgery Department, Faculty of Medicine, Gharian University- Libya
E-Mail: orthoakram@gmail.com

DOI: - 10.53555/ecb/2023.12.1073

Introduction:

Theories of pain generation include ligamentous or capsular tension, extraneous compression or shear forces, hypomobility or hypermobility, aberrant joint mechanics, and imbalances in the myofascial or kinetic chain that result in inflammation and pain , Intra-articular sources of SIJ pain include osteoarthritis; extra-articular sources include enthesis/ligamentous sprain and primary enthesopathy. In addition, ligamentous, tendinous, or fascial attachment and other cumulative soft tissue injuries that may occur posterior to the dorsal aspect of the SIJ may be a source of discomfort **(1).**

There are three possible causes of SIJ pain: (1) an increased mechanical load transfer onto the SIJ after fusion; (2) bone graft harvesting in the iliac crest close to the joint; and (3) the misdiagnosis of an SIJ syndrome before fusion (i.e., the lumbar spine is thought, erroneously, to be fused)**(2).**

Numerous clinical and experimental studies of adjacent segment disease after lumbar fusion procedures have demonstrated increased mobility in the adjacent cephalad and/or caudad segments and increased stress on the facet and/or disc of adjacent mobile segments **(1)**

In the case of lumbosacral fusion, the SIJ is the joint adjacent to the fused segment, and similar biomechanical responses could apply to the SIJ. Ha et al. reported that the incidence of SIJ degeneration is higher in patients in whom fusion is down to S1 than in patients in whom fusion is down to L5 studies reported increased SIJ uptake on single photon emission computed tomography (SPECT) after lumbar fusion and/or laminectomy and concluded that increased SIJ uptake is usually caused by changes in spinal mechanics. Although the differences failed to reach statistical significance, **(3)** reported a trend for more cases of SIJ pain in patients with fusion to the sacrum than in those without. Furthermore, **(4)** reported that patients with lumbosacral fusion had an increased frequency of positive SIJ blocks than those without **(1).**

A history of bone graft harvesting is a potential risk factor for SIJ pain. After discounting the SIJ as the etiologic source of pain based on a lack of objective findings on physical examination and imaging studies,**(5).** concluded that sacral sulcus pain encountered in 37 % of patients with low back pain after lumbar fusion was related to the iliac graft donor site **(1)**

The presence of a misdiagnosed sacroiliac syndrome as a cause of pre-fusion low back pain is also a possibility. Some patients may have lumbar fusion for misdiagnosed SIJ syndrome or some may have only lumbar fusion for lumbar pathology and SIJ syndrome. **(6)**reported that up to 14.5 % of patients presenting to a spine surgeon's clinic for low back pain had SIJ pathology **(6).**

In very rare cases, SIJ pain may be caused by hardware. For example **(7)** reported iatrogenic SIJ syndrome caused by the screw head and rod of percutaneous pedicle screw fixation at the L5–S1 level. The sharp rod tip and the laterally located screw head may irritate the iliac crest and distract the SIJ, leading to intractable SIJ pain **(7).**

Biomechanics of The Sacroiliac Joint

Motions of the SIJ:

The main function of the SI joint is to provide stability and attenuate forces to the lower extremities. The strong ligamentous system of the joint makes it better designed for stability and limits the amount of motion available **(8)**

Nutation: occurs as the sacrum moves anteriorly and inferiorly while the coccyx moves posteriorly relative to the ilium **(9)**

This motion is opposed by the wedge shape of the sacrum, the ridges and depression of the articular surfaces, the friction coefficient of the joint surface, and the integrity of the posterior, interosseous, and sacrotuberous ligaments that are also supported by muscles that insert into the ligaments **(10).**

Counter nutation: occurs as the sacrum moves posteriorly and superiorly while the coccyx moves anteriorly relative to the ilium**(9).**

This motion is opposed by the posterior sacroiliac ligament that is supported by the multifidus **(9).**

SIJ laxity:

The conclusion of these latter studies is that a relation exists between pelvic asymmetric laxity and the severity of complaints. Damen et al. state that subjects with asymmetric laxity of the SIJ during pregnancy have a threefold higher risk of moderate to severe pelvic pain persisting into the post-partum period, compared with subjects with symmetric laxity during pregnancy, and that pelvic belt application can diminish the laxity and stiffen the pelvis. Based on the above-mentioned studies, a dysfunctional SIJ is normally not related to a subluxated position of the joint, but to increased or decreased compression/force closure due to asymmetric forces acting on the joint **(11)**.

SIJ stability: a model based on form and force closure

Form Closure

Form Closure describes the stability of the joint from the design of the pelvic anatomy. The sacrum and the ilium each have one flat surface and one

ridged surface which interlock together, promoting stability**(12).**

The symmetrical grooves and ridges allow the highest coefficient of friction of any diarthrodial joint and protect the joint against shearing. The position of the bones in the SIJ creates a "keystone-like" shape which adds to the stability in the pelvic ring. This "keystone" shape is created, as the sacrum has a wider side superiorly, which allows the sacrum to be "wedged" in between the ilium **(12)**.

Force Closure:

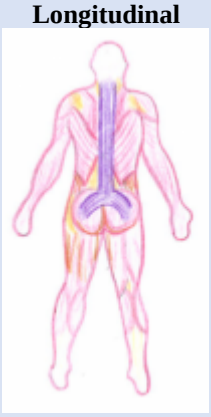
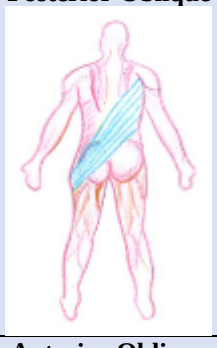
Although form closure provides stability to the SIJ, for mobility to occur further joint compression and stabilisation is required to withstand a vertical load. Force closure is the term used to describe the other forces acting across the joint to create stability **(12).**

This force is generated by structures with a fibre direction perpendicular to the sacroiliac joint and is adjustable according to the loading situation. Muscles, ligaments and the thoracolumbar facia all contribute to force closure Force closure is particularly important during activities such as walking when unilateral loading of the legs creates shear forces **(12).**

Force closure creates greater friction and therefore increased form closure and what is called "self-bracing" or "self-locking" of the joint. According to Willard et al. force closure reduces the joint's "neutral zone" thereby facilitating stabilisation **(12).**

As the ilium and sacrum only meet for approximately a third of the surfaces, the rest of the stability between the bones is provided by the ligaments **(12).**

Table (1): Shows three muscle slings that contribute to force closure of the SIJ, the longitudinal, posterior oblique and anterior oblique slings.

Name of Sling: Longitudinal 	• Multifidus attaching to the sacrum • Deep layer of thoracolumbar facia • Long head of biceps femoris attaching to the sacrotuberous ligament	• Contraction of the sacral part of the multifidus causes the SIJ to nutate thereby increasing tension in the interosseous and short dorsal ligaments and creating increased force closure of the SIJ. The iliac connections of this muscle along with the erector spinae muscle also pull the posterior sides of the iliac bones toward each other, limiting further nutation. • The muscles of this sling, particularly the multifidus, cause the thoracolumbar fascia to inflate increasing force closure. • Contraction of the erector spinae muscle and the long head of the biceps femoris can help to increase force close due to their anatomical connections with the sacrotuberous ligament
Posterior Oblique 	• Latissimus dorsi and contralateral • Gluteus maximus • Biceps femoris	• These muscles work as synergists to directly stabilise the SIJ. • Force closure can be increased indirectly due to the anatomical connections of the gluteus maximus and the thoracolumbar facia with the sacrotuberous ligament.
Anterior Oblique 	• External oblique • Internal oblique • Transverse abdominu	• These muscles connect via the rectus sheath and help to increase force closure

Deep muscles including the transverse abdominis, the middle part of the internal oblique, multifidus, the diaphragm, the piriformis and the pelvic floor muscles all exhibit anticipatory stabilising contractions prior to large movements. These deep muscles are closer to the centres of rotation of the spine and the SIJ and are therefore able to exert a greater compressive force on the SIJ**(11).**

In addition, the pelvic floor muscles oppose lateral movements of the coxal bones thereby stabilising the position of the sacrum between the coxal bones. Evidence has shown that SIJ stability increases with even slight muscle contraction.Even resting muscle activity, as well as active muscle contraction, causes compression of the SIJ joint surfaces **(11).**

Sacroiliac Joint Dysfunction

Sacroiliac joint dysfunction generally refers to pain in the sacroiliacjoint region that is caused by abnormal motion in the sacroiliac joint, either too much motion or too little motion. It typically results in inflammation of the sacroiliac joint, and can be debilitating **(13).**

Signs and symptoms:

Common symptoms include lower back pain, buttocks pain, sciatic leg pain, groin pain, hip pain (for explanation of leg, groin, and hip pain), urinary frequency, and "transient numbness, prickling, or tingling." Pain can range from dull aching to sharp and stabbing and increases with physical activity**(13).**

Symptoms also worsen with prolonged or sustained positions (i.e., sitting, standing, lying). Bending forward, stair climbing, hill climbing, and rising from a seated position can also provoke pain. Pain is reported to increase during menstruation in women. People with severe and disabling sacroiliac joint dysfunction can suffer from insomnia and depression **(14)**

Causes of Sacroiliac joint dysfunction

• Hypermobility

SI joint dysfunction is sometimes referred to as "sacroiliac joint instability" or "sacroiliac joint insufficiency" due to the lack of support the once strong and taut ligaments can no longer sustain **(15).**

When the joint is hypermobile or loose, it is classified as an extra- articular dysfunction because abnormal joint movement and alignment is a consequence of weakened, injured, or sprained ligaments, while the joint itself is structurally normal and healthy. The sacroiliac joint itself often will not show degenerative changes, such as arthritis, until many years of the dysfunction being allowed to continue **(15).**

Injury to the ligaments that hold the sacroiliac joints in proper support is thought to be caused by a torsion or high impact injury (such as an automobile accident) or a hard fall, resulting in the hypermobility. As many as 58% of people diagnosed with sacroiliac joint pain had some inciting traumatic injury based on clinical examination findings **(15).**

The joint that was once stabilized by strong ligaments, now overly stretched, sprained, or torn, will move beyond its normal range. This is thought to result in the ilium and sacral surfaces "locking" in an incongruent or asymmetrical fashion (one innominate bone is tilted anteriorly; the other innominate bone is tilted posteriorly) causing pain that can be debilitating **(16)**.

Hormone imbalances, particularly those associated with pregnancy and the hormone relaxin, can also cause a ligamentous laxity resulting in the weakening of the sacroiliac structure. During pregnancy, relaxin serves as nature's way of allowing the female pelvis to achieve distention of the birthing canal **(17)**

Pelvic joint pain in post pregnancy women is thought to be derived from the inability of the stretched out ligaments to return to normal tautness. Women who have delivered large babies or who have had extended labors also are prone to developing chronic sacroiliac joint pain and instability**(18)**

In some people, the sacroiliac joints reverse the normal concave- convex 'locking' relationship, which can lead to rotational misalignment. The variation in joint configuration results in some sacroiliac joints being inherently weaker or more prone to misalignment **(16)**.

Certain biomechanical or muscle length imbalances may ultimately predispose a person to sacroiliac dysfunction and pain. Likely, this is a result of altered gait patterns and repetitive stress to the SI joint and related structures. These conditions exist in persons with leg-length inequality, scoliosis, a history of polio, poor-quality footwear, and hip osteoarthritis **(16)**.

There is also a notable incidence of lumbar spinal fusion patients that present with sacroiliac pain and hypermobility, potentially due to the adjacent lumbar joints being fixed and unable to move. Clinical studies have found up to 75% of post-lumbar fusion patients develop SI joint degeneration within five years of surgery**(16)**

• Hypomobility:
Pathological hypomobility (too little movement) of the sacroiliac joint is an intra-articular disorder in which the joint locks due to wearing down with age or degenerative joint disease. Hypomobility of this kind can also occur with an inflammatory disease such as ankylosing spondylitis, rheumatoid arthritis, or an infection **(17).**

References:

1. Yoshihara H. Sacroiliac joint pain after lumbar/lumbosacral fusion: current knowledge. Eur Spine J. 2012;21(9):1788-96.
2. Maigne JY, Planchon CA. Sacroiliac joint pain after lumbar fusion. A study with anesthetic blocks. Eur Spine J. 2005;14(7):654-8.
3. Maigne J, Planchon C. Sacroiliac joint pain after lumbar fusion. A study with anesthetic blocks. European Spine Journal. 2005;14:654-8.
4. DePalma MJ, Ketchum JM, Saullo TR. Etiology of chronic low back pain in patients having undergone lumbar fusion. Pain medicine. 2011;12(5):732-9.
5. Frymoyer JW, Howe J, Kuhlmann D .The long-term effects of spinal fusion on the sacroiliac joints and ilium. Clinical Orthopaedics and Related Research®. 1978;134:196-201.
6. Sembrano JN, Polly DW, Jr. How often is low back pain not coming from the back? Spine (Phila Pa 1976). 2009;34(1:(E27-32.
7. Ahn Y, Lee SH. Iatrogenic sacroiliac joint syndrome after percutaneous pedicle screw fixation at the L5-S1 level: case report. Neurosurgery. 2010;67(3):E865-6; discussion E6.
8. Cohen SP. Sacroiliac joint pain: a comprehensive review of anatomy, diagnosis, and treatment. Anesth Analg. 2005;101(5):1440-53.
9. Levangie PK, Norkin CC. Joint structure and function : a comprehensive analysis. 4th ed. Philadelphia, PA: F.A. Davis Co. Philadelphia, PA; 2015.
10. Le Huec JC, Tsoupras A, Leglise A, Heraudet P, Celarier G, Sturresson B. The sacro-iliac joint: A potentially painful enigma. Update on the diagnosis and treatment of pain from micro-trauma. Orthop Traumatol Surg Res. 2019;105(1s):S31-s42.
11. Vleeming A, Schuenke MD, Masi AT ,Carreiro JE, Danneels L, Willard FH. The sacroiliac joint: an overview of its anatomy, function and potential clinical implications. J Anat. 2012;221(6):537-67.
12. Vleeming A, Schuenke M. Form and Force Closure of the Sacroiliac Joints. Pm r. 2019;11 Suppl 1:S24-s31.
13. Falowski S, Sayed D, Pope J, Patterson D, Fishman M, Gupta M, et al. A review and algorithm in the diagnosis and treatment of sacroiliac joint pain. Journal of pain research. 2020:3337-48.
14. Cohen SP, Chen Y, Neufeld NJ. Sacroiliac joint pain: a comprehensive review of epidemiology, diagnosis and treatment. Expert Rev Neurother. 2013;13(1):99-116.
15. Enix DE, Mayer JM. Sacroiliac joint hypermobility biomechanics and what it means for health care providers and patients. PM&R. 2019;11:S32-S9.
16. Kiapour A, Joukar A, Elgafy H, Erbulut DU, Agarwal AK, Goel VK. Biomechanics of the Sacroiliac Joint: Anatomy, Function, Biomechanics, Sexual Dimorphism, and Causes of Pain. Int J Spine Surg. 2020;14(Suppl 1):3-13.
17. Fiani B, Sekhon M, Doan T, Bowers B, Covarrubias C, Barthelmass M, et al. Sacroiliac Joint and Pelvic Dysfunction Due to Symphysiolysis in Postpartum Women. Cureus. 2021;13(10):e18619.
18. Verstraete EH, Vanderstraeten G, Parewijck W. Pelvic Girdle Pain during or after Pregnancy: a review of recent evidence and a clinical care path proposal. Facts Views Vis Obgyn. 2013;5(1):33-43.