Traumatic Soft Tissue Injuries Of The Spinopelvic Ring: How To Avoid Being Hooped

Armstrong, John B., MD, PhD (Complex Chronic Pain Physician), Kotopski, Dean A., BScPT, CAc/IMS, RMT

Introduction:

About 60-70% of individuals who complain of persistent, nonsurgical low back pain have spinopelvic ring dysfunction usually with involvement of the lower lumbar segments (L4-5 and L5-S1) and/or the sacroiliac joints (SIJs). These individuals characteristically have chronic low back pain that is increased by spinal movement, as in twisting and bending, and by spinal loading, as occurs with lifting and the prolonged maintenance of upright static postures such as sitting and standing. The low back pain can be radicular or non-radicular. Low back pain attributable to spinopelvic ring dysfunction is often encountered after childbirth, a slip and fall onto the buttocks, or a motor vehicle accident (MVA).

A routine assessment and a "one-size fits all" approach to rehabilitation generally work for 85-90% of those individuals who sustain axial soft tissue injuries in an MVA. Indeed, the report of the Quebec Task Force suggested that most individuals recovered irrespective of the treatment modalities provided. Individuals in the 10-15% group whose recovery is delayed with standard care should be carefully re-evaluated for an underlying and aggravating and/or perpetuating condition that complicates the clinical presentation of the patient and must also be successfully addressed in aid of recovery. Otherwise an incomplete examination leads to an incomplete understanding of the patient's problems. Not treating on the basis of a comprehensive diagnosis generally results in treatment failure for such individuals.

Spinopelvic ring instability and misalignment caused by disturbances of mobility at the sacroiliac joints should, in our opinion, always be looked for, and if inapparent at the outset, by serial examinations over time, when recovery from axial soft tissue injuries is delayed and prolonged. In our opinion, at the very least, all patients who have not fully recovered should be examined for spinopelvic ring dysfunction by the end of the subacute stage (up to 3 months after an MVA). Early detection allows earlier, effective intervention which provides better outcomes.

Spinopelvic ring dysfunction is frequently not considered by caregivers or, if it is and the diagnosis is made, its importance in the overall maintenance of the individuals complaints is often not appreciated or treated. Failure to understand and treat spinopelvic ring dysfunction leads to lengthy periods of misdirected and ineffective therapy with significantly prolonged delays in recovery.

Because spinopelvic ring dysfunction is dismissed by many clinicians as a non-entity and the methods of assessment are controversial, requiring experience to master, the condition is all too often ignored by invoking the rationale that the ring is powerfully supported and simply not susceptible to injury in the absence of a pelvic or sacral fracture. Yet, to our knowledge, nobody has advanced any other explanation as to why 10-15% of individuals fail to recover after an MVA. We will provide evidence that ignoring this condition is no longer justified diagnostically or therapeutically.

Anatomy (Structure) of the Spinopelvic Ring:

The spinopelvic ring is comprised of the two lower lumbar segments (L4-5 and L5-S1), the sacral promentory and SIJs at the back; the semi-circular pelvic brim around each side; and the symphysis pubis in front. The spinopelvic ring depends on strong soft tissue support for normal function. A woman's spinopelvic soft tissues are less robust and resilient than a man's so women, more often than men, sustain a soft tissue injury to the spinopelvic ring.

The SIJs are sturdy and are the largest of our axial joints, the smaller ones being the intervertebral facet joints and the temporomandibular joints (TMJs). The anterior portion of the joint is a boot-shaped synovial articulation with a capsule. Posteriorly, the joint is a syndesmosis, the very strong interosseous ligaments substituting for a capsule and binding the sacrum to the ilium on each side without an actual articulation between the two bony surfaces. The surfaces of the anterior synovial joint are invested with cartilage overlying the iliac and sacral sides of the articulation.

The SIJs are highly adapted anatomically to maintain **form closure**, that is, tightness of fit between joint surfaces. Even more importantly, there are powerful elements of soft tissue structure and function that embrace the joints, limiting movement in all planes and providing most of the stability for the spinopelvic ring. The soft tissue component that, together with form closure, maintains the close pack position that stabilizes the SIJs, is referred to as **force closure** and has been studied extensively in human cadavers but also in live subjects using ambulatory electromyography (EMG) during postural shifts and in walking.

The stabilizing soft tissues include the anterior joint capsule, ligaments, fascia, and muscles of the abdomen, spine, hip, and pelvic floor.

The key anterior ligaments are mid-line or present on both sides. The sacrum is connected with the pelvis by the anterior sacroiliac (blends with the joint capsule), the iliolumbar(??), and the sacrospinous ligaments. The hip bone (femur) is connected with the pelvis by the ilio- and pubo-femoral ligaments. The sacrum is connected with the tailbone (coccyx) by the anterior (mid-line) and lateral sacrococcygeal ligaments.

The key posterior ligaments are also mid-line or present on both sides. The sacrum and the pelvis are connected by the interosseous, the long and short posterior sacroiliac, and the sacrotuberous ligaments. The hip bone and pelvis are connected by the ischio-femoral ligament. The sacrum is connected with the tailbone by the mid-line posterior sacrococcygeal ligament.

Physiology (Function) of the Spinopelvic Ring:

The primary functions of the spinopelvic ring, thought by many to be static, are actually dynamic and include (a) providing a solid foundation for the spinal axis from the base of the skull to the coccyx; (b) maintaining normal posture and spinal alignment; (c) balancing axial movement and distributing axial loads; (d) accomplishing load transfer from the spinal axis to the lower extremities and from one lower extremity to the other, (e) reducing torque transmitted from normal rotational forces in the lower extremities and allowing for the smooth transmission of such forces up the spine, and (f) being a shock absorber to protect the spine from excessive forces following trauma in the lower extremities and buttocks when these forces are transmitted upwards to the spinopelvic ring through the hip joints.

Functional control of the spinopelvic ring is complex and not entirely understood. There is a dynamic, finely tuned interplay between the lower lumbar segments, the hip joints, the SIJs and the symphysis pubis that determines ligamentous laxity about the ring and hence the amount of movement within and the alignment of the ring??. This interplay is generally not under the control of the conscious mind and is accomplished continuously through the central and peripheral nervous systems. Normal function depends on the integrity of the soft tissues and their precise and continuous sensory neural inputs and feedback neural motor responses. Any disruption to this complex network causes spinopelvic ring dysfunction, resulting in axial pain and diminished physical capacity.

Some muscles have attachments to the ligaments and fascia supporting the spinopelvic ring and the control system can be modulated during complex motor activities such as smoothly transferring axial loads from one lower extremity to the other as in walking, running or kicking a field goal. This modulating system depends on finely coordinated neuromuscular firing. If any part of the soft tissue mechanism is impaired as, for example, by injury, modulation is perturbed and a dynamic spinopelvic and axial misalignment can result, causing symptoms of pain and limited physical capacity that can occur in the low back but can also be transmitted throughout the spinal axis, including the shoulder, hip and pelvic girdles, and into the upper and lower extremities.

Normally, the SIJs are capable of very little movement but nonetheless is in all directions. Movement is not the result of any muscular contraction but is the result of varying tensions in the supporting soft tissues. Contraction of the key muscles stabilizing the spinopelvic ring (a) facilitates normal rotational mobility (nutation or froward flexion of the sacrum with posterior rotation of the pelvis and counter-nutation or extension of the sacrum with anterior rotation of the pelvis), (b) maintains normal alignment, and (c) resists excessive rotational forces and abnormal shear forces acting on the pelvis in an upwards, downwards, forwards, and backwards direction or causing the pelvis to flare in or out.

Mechanism of Injury of the Spinopelvic Ring:

The two lower lumbar segments are subject to degeneration of the intervertebral discs and the intervertebral joints including the facet joints. Such changes can weaken the spinopelvic ring, causing it to become unstable. Instability at one point in the ring can produce strain that is transmitted to another point in the ring, especially to the SIJs, which additional strain can lead to SIJ dysfunction resulting in misalignment and additional instability of the ring.

Normally, movement at the SIJs is limited by form and force closure to only a few degrees. Mobility can increase with the development of joint laxity as occurs with traumatic strain (excessive stretch) or sprain (tearing) of the supporting ligaments, capsule and fascial attachments. Any disruption of the neuromuscular modulating system by soft tissue injury, myofascial disorder, and/or musculo-ligamentous deconditioning will adversely impact joint laxity. Risk factors for such injuries are female gender, previous childbirth, spondylosis in the lower lumbar segments, previous low back surgery, repetitive torsional strain in the lower extremities, repetitive axial loading and/or mechanical strain, true leg length discrepancy, primary arthropathy of the SIJ, and generalized joint laxity, a variant of normal.

In an MVA, soft tissue injuries to the spinopelvic ring can occur when the individual is using a lap belt, one or both legs are braced against the foot controls or floor of the vehicle, or one or both knees strike the dash. Compared to the lumbar spine, the SIJs are not nearly as resilient to rotational forces or to axial compression so in the standard whiplash situation these joints are more vulnerable to sudden axial loading and abrupt rotational forces, especially when the pelvis is relatively fixed by a lap belt. It might be the fault of the relatively weak anterior capsule, the Achilles heel of the SIJ, which can give way in these circumstances.

A hard fall onto the buttock is also a mechanism of injury in which there is shear force exerted on the spinopelvic ring which cannot be overcome by the supporting soft tissues and causes the soft tissues to be strained or sprained resulting in increased SIJ mobility and displacement, often into innominate upslip on one side or the other or both.

Clinical Considerations - Diagnosis:

When one is taking a history, there are key symptoms to keep in mind. A careful representation of the patient's pain should be recorded using a pain diagram. It is important to remember that spinopelvic ring dysfunction can exist when there is little or no low back pain. We have seen individuals whose principal complaint was headache. They were found to have spinopelvic ring dysfunction, the associated axial misalignment having been the cause of myofascial tension and trigger points in the soft tissues of the neck that were responsible for the headaches, these being relieved when the spinopelvic ring dysfunction was corrected and normal soft tissue function in the neck was restored.

When low back pain is present, it typically is aggravated by both mechanical factors (e.g. repetitive twisting and bending) and by spinal loading (e.g. prolonged sitting or stooping). Pain might be localized to the sacroiliac area but not necessarily. When present, the typical pattern for referred SIJ

pain is in the ipsilateral groin, buttock and thigh (anteriorly and/or posteriorly) but usually not extending below the knee.

The piriformis muscle is often affected in spinopelvic ring dysfunction because it shortens in trying to bring increased stability to the ring. In so doing, it becomes bulky and has a tendency to go into spasm and may, itself, be the cause of pain and tenderness in the buttock. The sciatic nerve runs under or through the muscle and easily becomes entrapped in the greater sciatic notch of the pelvis, either within the muscle or against the sharp edge of the sacrospinous ligament, resulting in radicular-like pain and/or numbness which, unlike true radicular symptoms, is poorly localized and appears to involve more than a single dermatome. The pudendal nerve can be similarly entrapped resulting in urinary frequency and genital pain and numbness. The gluteal nerves are also entrapped by the piriformis muscle and this results in pain and numbness of the buttock on the same side. The sacrotuberous ligament has a distinctive referral pattern of pain and numbness which is in a narrow band down the back of the leg and into the heel.

Patients with spinopelvic ring dysfunction find sitting for long periods is very uncomfortable and they will advise and, in fact, can be seen to do so, that they must constantly shift their weight from one buttock to the other to manage this discomfort. It is important to ask about any clunking or clicking sensation in the low back which occurs when a locked SIJ releases as when extending the thigh from a flexed position in standing up after being seated in a chair.

Physical examination of the patient should begin with a careful inspection of stance and gait. In particular, the stance might reveal inconsistencies in head tilt, shoulder height, and waist fold symmetry. A scoliosis might be present and this can be shown to be compensatory by having the patient lie prone on the exam table when the scoliosis will be observed to disappear.

Inspection and palpation of the iliac crests should be performed to see if both are at the same level and are symmetrically positioned and if they are tender. This should be done from the posterior and anterior vantage points so that subtle misalignment as occurs when the pelvis is flared or advanced forward is not overlooked. The posterior superior iliac spine (PSIS) should be palpated on each side for tenderness and to see if they are level with one another.

Pain and tenderness can be experienced at the iliac crest and at the PSIS. The iliac crest and PSIS are respectively the insertion site (enthesis) for the iliolumbar and the long posterior sacroiliac ligaments, important supporting structures for the sacroiliac joint on e the same side. In the presence of spinopelvic ring instability and misalignment resulting from sacroiliac joint hypermobility and subluxation, these ligaments become increasingly overloaded, strained, and irritable and exert excessive traction on their entheses, causing local irritation with pain and tenderness at the iliac crest and PSIS. Similarly, the insertion of the piriformis muscle on the greater trochanter (GT), the bony prominence on the upper outer aspect of the thigh bone, can become painful and tender when the piriformis muscle shortens in order to provide greater stability to the sacroiliac joint on the same side and, in so doing, exerts excessive traction on the GT. These phenomena cause what is referred to as enthesopathic pain and tenderness.

Examination of the spinopelvic ring requires regular practice so that difficult to execute diagnostic maneuvers can be performed consistently and reliably and ring dysfunction can be confirmed when it is present. These maneuvers provide static and dynamic testing. The two most common static tests are the Patrick test (or FABER for flexion, abduction and external rotation of the hip) and the Gaenslen test. Dynamic testing to provoke abnormalities in mobility and alignment is provided by the Gillet test. While there is considerable disagreement concerning the reliability of these tests, we have found that, after much practice, the Gillet test is very helpful in competent hands. Sometimes a click or clunk will be palpable and/or audible during the Gillet test and this occurs when a locked SIJ releases during the test.

The misalignments (relative to the sacrum) we have observed are anterior rotation, posterior rotation and upslip of the innominate bone and in-flare, out-flare and forward shift of the pelvis. The most common misalignments are anterior rotation and upslip. Sometimes one SIJ is involved and sometimes both are affected with a different misalignment on the two sides. In other situations, an anterior rotation may correct, for example, into posterior rotation or upslip. One joint might be locked and show no movement. It can sometimes be unlocked by squatting or by repetitive alternating knee raises.

Because spinopelvic ring dysfunction is a dynamic condition occurring in the upright posture (sitting or standing), it cannot usually be observed with standard imaging procedures such as a CT or MR scan because these techniques provide static images obtained with the patient lying on the back. When standing radiographs are taken in the presence of sacroiliac joint misalignment, stereoscopic images are needed in an effort to determine the nature of the pelvic asymmetry but this has not proved to be reliable. Since the problem is usually mechanical rather than inflammatory, radionuclide bone scans are also generally not helpful in establishing the diagnosis unless there is a primary arthropathy. In the future, it might become possible to demonstrate spinopelvic malalignment using noninvasive, positional MR imaging (pMRI) when, with the patient standing, the magnetic gantry can be placed like a donut around the lower spine and pelvis. It may also become possible to demonstrate sacroiliac joint instability dynamically using yet to be refined ultrasound techniques that are able to provide noninvasive, cinematic imaging of the joint in real time while the patient is standing and hypermobility is elicited using the Gillet test.

Injecting the SIJs with corticosteroid and local anesthetic under CT fluroscopic guidance, often espoused as the gold standard in diagnosis, has, in fact, been found to have inconsistent reliability because there are often additional extrinsic pain generators that can be greater sources of pain than the joint itself.

Clinical Considerations - Treatment:

Treatment for SIJ and spinopelvic dysfunction is largely based on physical therapy. Because of the lack of understanding of this condition by physicians, specialists and rehabilitative therapists problematic SIJ's are generally categorized as LBP. Because of their anatomical positioning near the lumbar spine this categorization is reasonably true however, we are of the opinion that this misnomer is part of the problem leading to ineffective treatment outcomes involving SIJ mediated pain.

It cannot be overstated that most chronic SIJ, lumbar spine and hip pain has at least some component of a mal-alignment of the innominate or pelvic bone. It also cannot be overstated that the vast number of clinicians responsible for diagnosing and/or treating mechanical deficit of these regions have little understanding of the role that innominate mal-alignment contributes to SIJ, lumbar spine and hip pathology. Indeed, clinically it is rare that we do not see pelvic obliquity when we have isolated the problem as SIJ dysfunction. Radiating pain to the SIJ region from muscular trigger point or corresponding nerve irritation are most likely culprit in these minimally seen cases. Furthermore, most cases involving chronic pain at the hip and lumbar spine that are not the result of osteoarthritis usually also involve some degree of pelvic obliquity. Indeed, we feel this to be a main factor why people progress to chronic lumbar spine pain and pre-mature wear of the hip joint which can lead to the need for hip replacement.

This takes us back to the absolute necessity for clinician expertise in diagnostics to be able to identify and isolate proper alignment and stability of the spinopelvic ring. The three main criteria in proper diagnosis are 1) identifying rotation and/or upslip of the innominate bone, 2) identifying if there is hypo or hypermobility at the SIJ and the surrounding lumbar and hip joints and 3) isolating mechanical weakness of key muscles affected by spinopelvic obliquity and/or instability.

The typical clinical scenario we encounter regarding a history of spinopelvic and/or hip pain is such: A patient is referred for assessment and treatment for low back and/or hip pain that won't go away. Typically these patients have had multiple visits to their physiotherapist, chiropractor, massage therapist or acupuncturist. When these treatment attempts fail to resolve the client's pain and if the mechanical problem is the result of a motor vehicle accident, they are sent for an active rehab program with a kinesiologist. This only tends to make the problem worse as now they are loading a mal-aligned and/or unstable spinopelvic region and the program is abandoned or short lived.

After a month or so of the "wait and see" approach failing to resolve pain and dysfunction they wind up on our doorstep. Following a thorough examination, almost always we encounter mal-alignment of the spinopelvic ring and the resultant pain patterns and weaknesses associated with this problem as well as some form of mechanical irritation involving the SIJ. More often than not when questioned the patient replies that the vast amount of testing they have just undergone has not been previously performed on them and if an obliquity was identified, restoration of normal spinopelvic alignment and stability was not the immediate and main focus of treatment.

Proper treatment for spinopelvic and associated SIJ pathology is based on a simple 3 phase philosophy: 1) align and stabilize the skeleton, 2) mobilize the skeleton (the soft tissues will follow suit) and 3) condition the surrounding soft tissues. It has been our experience that anything less comprehensive than this approach or treatment not done in this order leads to sub-standard results.

With specific reference to treating SIJ pain the therapist must first, as always, determine if a pelvic obliquity exists. Once this has been established a determination of whether an instability exists must also be established. It is our strong opinion that muscular control (force closure) cannot be initiated until joint stability/congruency (form closure) exists. Often this can be simply rectified with the use of an SI belt worn around the pelvis at the level of the hip trochanters. Another technique used to establish SIJ stability, although somewhat controversial, is PRP prolotherapy. Prolotherapy acts to increase the

"bulk" of the dorsal sacral ligaments thereby providing an increased measure of posterior ligamentous stability. We have used this technique with a number of our patients achieving moderately good success.

Once alignment and joint stability have been achieved we can then move to mobilizing the stiffness of the surrounding lower lumbar facet joints and, to a lesser degree, hip joints. Almost always as a direct result of SIJ dysfunction, increased compensatory pressure and movement will be experienced at the lower lumbar facet and sometimes hip joints. This will secondarily place greater strain on the supporting paralumbar and hip musculature.

Techniques used here must include specific manual therapy to free "stuck" facets and loosen hypertonic musculature. Stretching and acupuncture including IMS and trigger point injection are excellent techniques to loosen taught bands of muscle. Also, various form of electric muscular stimulation can be used as an adjunct to reduce local pain and free muscles from spasm. We are of the belief that these techniques should be coupled together with specific stretch techniques administered concurrently so as to achieve maximum result.

Finally, conditioning of the lumbopelvic core, gluteal and hip flexor and abductor musculature is essential to ensure maintenance of spinopelvic symmetry and maximum mechanical function of associated spinopelvic musculature.

Clinical Considerations: Secondary Mechanical Pathology

In the past seven years that I have concentrated my efforts on understanding why patients progress to chronic low back, SIJ and/or hip pain I have unearthed one absolute truth: if a pelvic mal-alignment is identified and restoration of pelvic neutral is not the primary focus of treatment, the patient will not see appreciable gains in mechanical strength or restoration of functional movement patterns and will continue to experience only fleeting moments of pain relief. Why? Because the symptoms rather than the source of the problem are being addressed. This is both extremely costly for not only third party payers but the client as well as it is the client who pays for this improper treatment not only monetarily but emotionally as well. And the latter currency is far more "expensive" than all others.

It is important to remember one point when restoring function to any mechanical system: one cannot expect to normalize mechanical function to a system if the framework of the system in question is allowed to remain incongruent or mal-aligned.

How could a physical therapist ever expect to de-pressurize a lumbar spine or SIJ that is resting on a twisted foundation (the sacrum)? How could a therapist ever expect to rid their client of an impinging hip joint with or without chronic hip flexor tendonitis when the innominate or pelvic bone is rotated? These was the very question that plagued us for years. That is: why, despite our best efforts, are 10-15% of our clients not responding to conventional treatment such as standard strength and stretch exercises, manual therapy and various electro-modalities?

The answer, we now know, is because the vast majority of these patients are most likely dealing with

spinopelvic mal-alignments.

Typically when we observe a pelvic mal-alignment these signs are present:

1. Weakened ipsilateral iliopsoas and gluteus medius muscles(can appear as Trendelenberg gait)
2. Weakened contralateral lumbar erecor spinae
3. Ipsilateral long leg-length discrepancy
4. Increased external rotation ipsilateral hip joint(due to anterior rotation of innominate)
5. Hypomobility ipsilateral SIJ
6. Hypomobile ipsilateral L5-S1 facets(due to increased extension moment from anterior rotated innominate)
7. Subluxation of ipsilateral symphysis pubis
8. Increased ankle pronation with secondary increased stress on plantar fascia, tibialis posterior and Achilles tendon
9. Hypertonic ipsilateral lumbar paraspinals, rectus femoris, gluteus medius and piriformis muscles
10. Overstretched ipsilateral iliopsoas and hamstrings

One can immediately see that with this extensive list of secondary sequelae it becomes absolutely vital to rule out spinopelvic obliquity when treating issues that involve the spinopelvis, thoracic and cervical spines as well as the lower extremities.

Let us look at a common clinical problem we deal with on a regular basis: unilateral or one-sided lower back pain of the right side. When a client presents with lower back pain on one side we immediately check lumbar, SIJ and hip range of motion as well as strength of surrounding musculature especially hip flexors and abductors and the ability to recruit multifidii which constitute the bulk of the posterior core musculature.

If a pelvic mal-alignment is present the previously mentioned secondary resultants are usually present to some degree, especially if the case is chronic. In this case we are most concerned with the strength of the hip flexors and abductors and the lower erector spinae which typically will be weakened on the same aide as the pelvic mal-alignment. These muscles are directly responsible for dynamic stability of the lumbar spine and ultimately help maintain spinopelvic symmetry and mobility once functioning fully. The source of the pain is typically a subluxed or mal-positioned facet joint or joints and hypertonic musculature protecting the hypomobile lumbar segments.

The massage therapist commenting on and treating the tight right lumbar paraspinals and the chiropractor commenting on and manipulating the right L3-S1 facets would both be correct as to what the sources of pain in this particular low back are. And both would most likely have some success in alleviating their client's pain. The only problem here is that their success would be short lived as the true source of the problem driving the tight right paraspinals and the subluxed right lower facet joints is the anteriorly rotated innominate/pelvic bone.

This is also the source that drives most hamstring tears, piriformis syndromes, chronic lumbar facet subluxations, tendonitis involving Rectus Femoris and Sartorius, Trendelenberg gaits and a significant

amount of IT Band syndromes with concurrent or non-concurrent plantar fasciitis.

The secondary sequelae from a mal-aligned innominate bone and ultimately spinopelvis are statistically significant. And clinically we successfully resolve most of these cases when our first goal is to restore the spinopelvis to neutral alignment thus immediately restoring dynamic stability to the hip flexors and abductors and lower lumbar erector spinae without the client stepping one foot into a gym to undergo strength training!

Ultimately strength training is what will maintain spinopelvic alignment but we must remember that power is the resultant of three (3) components and not just one which we commonly see as the treatment approach to low back pain. We MUST align and stabilize the skeleton, we are then allowed to progress to mobilizing the skeleton and surrounding soft tissues and FINALLY we can then properly proceed to a proper strength and conditioning program that holds it all in place and also gives us the stamina to do so. Incredibly simplistic but so often NEVER done.

SKELETAL ALIGNMENT/STABILITY	+	SKELETAL MOBILITY	+	MUSCULAR CONDITIONING	=	POWER!!!