Rethinking Superior and Inferior Sacroiliac Shear: A New Approach to Diagnosis and Treatment

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CLINICAL PRACTICE

Abstract

The concept of upslipped and downslipped innominate dysfunction has been a part of osteopathic teaching for more than 50 years. In more recent years, the terminology has evolved into superior and inferior innominate shears. The assumption that these somatic dysfunctions result from vertical shearing at the sacroiliac (SI) joint is evaluated in light of new research on sacroiliac motion and stability and the authors' clinical experiences. The authors propose that the apparent superior or inferior shift of an innominate is better accounted for by sidebending of the innominate at the sacroiliac joint. Altered treatments based on this new understanding are presented.

Background

The concept of superior or inferior shearing of the innominate along the long axis of the sacroiliac (SI) joint has been detailed in osteopathic literature and taught in osteopathic schools for more than half a century. The first published mention of innominate dysfunction was reported by Carl Phillip McConnell, DO, MD, in 1900. He wrote:

> To be able to diagnose accurately and intelligently the pelvic region requires nearly as much skill as in examining the cervical region. '... The pelvis as a whole may be tipped anteriorly or posteriorly upon the spinal column. It may also be twisted or rotated laterally upon the spinal column. The most common lesions are subluxations of an innoninatum forward, backward, upward or downward; or various combinations of these displacements, such as tipping forward and downward of an innominatum.[1]

Guy Dudley Hulett, DO, in 1904 wrote:

> In speaking of an upward subluxation of the ilium reference must be made to the direction of displacement. In many cases of such lesion of the innominatum the condition is really a rotation of the bone *about an axis passing horizontally through the pubic articulation* [emphasis added]. Usually the cause of the subluxated innominatum is a strong jarring of the bone transmitted through the femur, as in the case of stepping abruptly and unconsciously upon a lower level; in this case the force is transmitted by the *weight of the spinal column* [emphasis added] through the sacrum. In either case, the tendency will be for an upward sliding of the innominatum upon the sacroiliac articulation, but without necessarily a similar upward sliding at the junction of the two innominata.[2]

Another early reference regarding upslipped innominate dysfunction was written by Charles Owens in 1937: "As to the lesions themselves, one innominate may be twisted forward and the other backward, or either may be twisted independent of the other.…or, it may be slipped up or down on the sacrum."[3]

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The concept that the innominate could be sheared upward or downward at the sacroiliac joint was delineated as "upslipped and downslipped" innominate dysfunctions as a part of the muscle energy model developed by Fred Mitchell Sr., DO, FAAO.[4] It was first published in 1958 to explain and treat postural dysfunctions and pain syndromes. The structural findings proposed to demonstrate an upslipped or downslipped innominate included:

1. Superior or inferior iliac crest
2. Superior or inferior ischial tuberosity
3. Superior or inferior pubic tubercle
4. Superior or inferior posterior superior iliac spine (PSIS)
5. Superior or inferior anterior superior iliac spine (ASIS)

If all 5 of these landmarks were found to be superior in combination with a positive standing flexion test on the same side, this dysfunction was labeled an upslipped innominate. Conversely, if all 5 landmarks were found to be inferior in combination with a positive standing flexion test on the same side, it was labeled a downslipped innominate.[4,5] In the muscle energy model, these 2 dysfunctions were labeled iliosacral dysfunctions as the innominate moved around the fixed sacrum. The upslipped innominate was always accompanied by a short leg on the same side. Likewise, the downslipped innominate was accompanied by a lengthened leg.

In more recent years, it has become more common to use the term *superior innominate shear* for Mitchell's upslipped innominate and *inferior innominate shear* for what he termed a downslipped innominate.

Possible Causes of Innominate Shear

It has been hypothesized that both superior and inferior innominate shears are due to injury or trauma such as a motor vehicle accident, fall, stepping into a hole, etc.[4,5] The interpretation of these findings was that the sacroiliac joint had been subjected to shearing forces along the long axis of the body and developed a new ease at the end of its normal physiological longitudinal motion and a restriction from movement in the opposite direction. This left the innominate superior or inferior relative to the sacrum at the dysfunctional joint. Longitudinal shearing was presumed to be the result of severely abnormal vertical forces rather than the normal postural forces transmitted during standing or walking. Yet, in our clinical experience, we find that patients frequently present with the complaint of low back and/or pelvis pain with evidence of superior or inferior innominate shear, but they cannot recall any injury prior to the onset of their symptoms.

Other situations noted frequently in clinical practice by the authors as having been present and potentially causally related to superior or inferior innominate findings include viscerosomatic dysfunctions and sleeping in a lateral recumbent position without support of the upper leg. We also have observed that simply standing or sitting for a prolonged period with the majority of the body weight on one innominate can result in an upslipped innominate. Finally, the upslipped innominate is seen frequently when there is a pain-causing issue in that leg, presumably due to a nocifensive reflex similar to that seen when 4-legged animals lift the affected leg and walk on the other 3.

Another set of questions arose from the sacroiliac shearing model related to the inferior sheared innominate. First, if the inferior innominate shear was the result of an overwhelming force that sheared the innominate downward at the joint, it should be exceedingly rare. In fact, it is less common than a superior innominate shear. However, our clinical experience suggested that an inferior sheared innominate was, in fact, a fairly common diagnosis. Second, it was frequently seen in situations that did not involve significant force. Third, it was often seen in situations involving a superior innominate shear on the contralateral side. And finally, any inferior innominate shear should have been easily and spontaneously reduced by simply standing or sitting with most of the weight on that leg or hip. In fact, even the process of standing or even jumping with most of one's weight on the leg of the inferior innominate shear did not reduce the shear.

The primary factor that influenced the development of an alternative explanation for the apparent sacroiliac shearing was the magnitude of the leg length disparity caused by apparent sacroiliac shearing. In the supine patient, it could be well in excess of the 2 mm to 4 mm vertical motion allowed at the sacroiliac joint.[6] In the authors' experiences, many patients would demonstrate a functional leg length discrepancy that exceeded 13 mm (0.5 inch). On a number of occasions, the leg length discrepancy might be as much as 38 mm (1.5 inches).

Part of the apparent leg length disparity could be due to unleveling of the sacral base. However, it has been demonstrated that there is no consistency in the relationship between sacral base declination and apparent leg length discrepancy.[7] In fact, most sacral base unleveling is associated with L5 segmental dysfunctions, not with sacroiliac shears. Interestingly, Qureshi et al found the superior sheared innominate to be more common than either anterior or posterior rotated innominates when side was not considered and the left superior sheared innominate to be the most common innominate dysfunction overall.

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While part of the apparently excessive leg length discrepancy with innominate shears was found to be due to a simultaneous superior innominate shear on 1 side and an inferior innominate shear on the other, the leg length discrepancy was well in excess of the anatomical shearing allowed at the sacroiliac joint (which could be as much as 8 mm if both innominates were sheared). Even though part of the apparent leg length discrepancy might be due to longitudinal torsions involving the hip and leg, there was still too much of an apparent vertical shear in the sacroiliac joint. Newer research into sacroiliac joint anatomy, stability, and gait mechanics also began to cast doubt on whether any significant superior or inferior displacement of the innominate could truly occur without severe bony and ligamentous injury to the pelvis.

Anatomy of the Sacroiliac Joint

The sacroiliac joint in human beings is one of the most complex joints in the body. The joint surface is generally L-shaped with the short leg superior and the angle facing anterior. In about 20% of the population, it may be E-shaped or triangular.[8] The sacrum itself is the result of the fusion of 4 embryonic sacral vertebrae. The superior 3 (S1, S2 and S3) are involved in the sacroiliac joint.

The joint surface is highly irregular, but the majority involves a longitudinal concave surface on the sacral side and matching convex surface on the iliac (innominate) side. Both surfaces are covered in cartilage with the sacral surface being thicker. The joint space varies between 2 mm and 4 mm inferiorly.[7] A projection from the iliac side with a concomitant sacral indentation is sometimes noted at S2 and is considered the pivot area for sacral nutation and counternutation.[7]

In addition to the expected joint capsule enclosing the whole joint, there are a number of transverse supporting ligaments both anterior to the joint and posterior. Relatively, the posterior ligaments are among the thickest and strongest in the body. The anterior ligaments are still substantial but less robust than the posterior ligaments. Motion allowed by the anatomy of the joint itself and these powerful ligaments is between 2° and 18° of nutation/counternutation and up to 4 mm motion in any direction.[7]

The 2 primary muscle groups attaching to the sacrum are multifidis between the upper posterior sacrum and the PSIS and piriformis anteriorly and inferiorly. Piriformis inserts on the femur, bridging across the anterior surface of the ilium. Both have the potential of compressing the sacroiliac joint. Tendon slips from gluteus maximus also cross over the sacroiliac joint attaching to the posterior sacroiliac ligaments and the surface of the sacrum. Therefore, gluteus maximus has the potential to compress and stabilize the sacroiliac joint as well.[7,9]

Current Research

Research on the motion dynamics of gait has revealed that stability of the sacroiliac joint is a necessary component of gait mechanics and lumbo-pelvic stability. Vleeming et al have proposed the concepts of *form closure* and *force closure* to explain the stability that is necessary at the sacroiliac joints.[9] According to this concept, stability of the sacroiliac joint is a necessary component of lower back stabilization and normal gait mechanics. Form closure is achieved by the friction created by the articular surfaces of the sacroiliac joint and the anatomical arrangement of the joints. Force closure is a dynamic process achieved by the weight of the body in combination with ligament force and action of muscle groups. In essence, the trunk and lower extremity via the sacrotuberous ligament, hamstrings, gluteal mechanism, and trunk musculature act to create functional compression of the sacroiliac joint. Without sacroiliac stabilization, the body engages abnormal muscle sequential firing patterns. Eventually, the patient experiences low back pain as the result of these compensatory patterns.

If the body is truly dependent on sacroiliac stability and engages many ligamentous and muscular structures to guarantee this stability as proposed by Vleeming, it would take extraordinary forces to disrupt such stability. Most patients, unless they have experienced major trauma, will not experience an injury that could disrupt this intricate, strong interaction of neuromuscular and fascial compression forces. In fact, as detailed above, many patients with superior and inferior innominate shears report no injury at all prior to the onset of their findings.

Gracovetsky[10] has proposed a different theory of sacroiliac stability based on several reasons:

1. The SI joint is shaped with reverse angulation, creating a warped surface that cannot slide.
2. Irregular surfaces of the SI joint create high levels of friction.
3. The demonstrated presence of a bony ridge at the level of S2/3, which he named the SG ridge. Gracovetsky proposes that this ridge helps prevent dislocation of the SI joint. If the proposed function of the Gracovetsky ridge is correct, then the SI joint is designed with a bony buttress that prevents superior and inferior dislocation.
4. The high friction surfaces of the SI joint and the bony matrix beneath them are designed for bony compression, not to help prevent shear. Thus, the SI joint appears to be designed not to prevent instability and shear, but to maintain compression.

If the body uses multiple approaches to assure sacroiliac stability, and if shear is no longer a viable explanation for superior and infe-

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rior innominate shear dysfunctions, then a new approach needed to be developed to explain how the innominate can *appear* to be sheared relative to the sacrum. Indeed, could the innominate *appear* to be sheared superiorly or inferiorly but actually be tilted medially or laterally? Moreover, how would such mechanics occur?

Proposed Mechanism

Based on the new understanding of sacroiliac motion and stability, we sought to develop a better model to explain the physical findings of apparent innominate shearing. We propose the following new explanation.

Findings of superior or inferior iliac crest in the seated, supine, prone, and standing positions indicate a mechanical alteration of the normal innominate position in reference to the sacrum in agreement with prior models. Our proposed mechanism for this finding is the development of a force that produces medial or lateral *sidebending of the innominate on the sacrum.*

For what has been traditionally termed a superior innominate shear, the *sidebending* of the innominate causes a relative gapping of the sacroiliac joint inferiorly and compression of the joint superiorly. The pivot point would be at the area of the S2 prominence. The focus or restriction caused by this forced sidebending would be in the *superior* portion of the sacroiliac joint *(Figures 1a and 1b)*. The forced sidebending of the innominate on the sacrum imbalances the joint, increases the friction superiorly and changes the balance of the compression caused by the multifidis muscles superiorly and the piriformis inferiorly. In the absence of a new force that would rebalance the sacroiliac joint, this dysfunctional state becomes the new norm.

In the sidebent model, the iliac crest would be closer to the midline and the acetabulum, and therefore, the femoral greater trochanter will be more lateral. *The leg on the affected side will appear to be shorter. It would also require the leg to be relatively abducted in order to remain parallel with the other leg*. The anterior superior iliac spine (ASIS) and the posterior superior iliac spine (PSIS) along with the iliac crest would be more superior relative to their non-dysfunctional states.

Standing on the leg on the dysfunctional side will reinforce the sidebending at the sacroiliac joint since it will create a superior force vector along the axis of the leg. An outside force is required to return the innominate to its normal position and function.

Conversely, an inferior innominate shear is the result of a forced sidebending of the innominate toward the *inferior* part of the sacroiliac joint. The superior part of the joint becomes gapped and the inferior part compressed. In this situation, the pelvic brim is shifted *outward* to become more lateral relative to the midline, and the lower part of the innominate is shifted *inward* or closer to the midline. The *iliac crest* presents inferior to its normal presentation as do the ASIS and PSIS. Also, the acetabulum and greater trochanter become relatively medial and inferior to their normal positions. To remain parallel to the other leg, the leg on the inferior sheared innominate will be *slightly abducted and the leg will appear to be lengthened*. Again, standing on the leg of an "inferior sheared

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Figure 1a. *Normal relationship between sacrum and innominate, anterior view.*

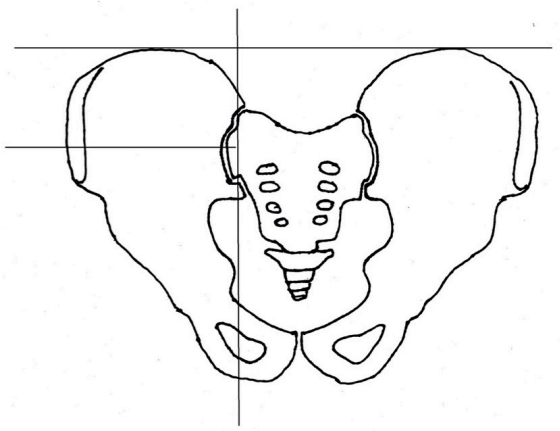
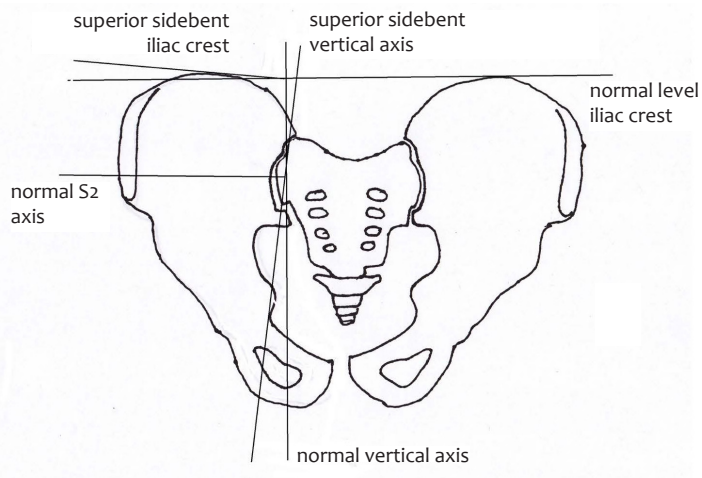


Figure 1b. *Right innominate supriorly sidebent at sacroiliac joint. ASIS and iliac crest are superior relative to the unaffected side.*



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innominate" will merely reinforce the abnormal position rather than reducing it if the innominate is sidebent.

If we assume that the maximal vertical shearing available at the sacroiliac joint is 4 mm,[7] then that should be the maximum displacement of the innominate if it is sheared upward or downward as proposed by previous models. Each innominate itself averages 135 mm in width in the adult, and the sacral base is 106 mm wide. The average long-axis length of the sacroiliac joint is 52.17 mm (SD 5.29 mm) and the average short axis breadth is 38.96 mm (SD 3.85 mm).[8] We can assume that the sacroiliac joint allows a maximum lateral deviation of 4 mm at either the sacral base end of the joint or sacral apex end of the joint. Calculations then suggest that the lateral innominate or iliac crest potentially could show a dorsal or ventral excursion of 10.35 mm if the innominate sidebends or pivots at S2. As noted previously, the data suggest that the innominates are not primarily sheared upward or downward in what has traditionally been termed innominate shearing. If there is also some vertical shearing, it would be a secondary motion contributing perhaps an additional 4 mm to the apparent innominate displacement.

Obviously, the ongoing use of the term innominate shear becomes awkward because it is an inaccurate portrayal of the actual processes. Thus, a more accurate description of innominate shears should be as follows:

- **Superior sidebent innominate** *(previously called superior innominate shear)*: Emphasizing that the superior aspect of the sacroiliac joint is where the sidebending compression occurs also provides continuity with the prior identification of the dysfunction as a superior innominate shear.
- **Inferior sidebent innominate** *(previously called inferior innominate shear)*.

We propose that reversing the sidebending movements of the innominate should reset the innominate back in its functionally normal position in relationship to the sacrum.

According to this model, the ASIS, ischial tuberosity, iliac crest, and PSIS landmarks will all be superior in the supine and prone positions in a superior sidebent innominate. The pubic symphysis could remain level as the innominate is not truly sheared upward. However, the pubic bone could be either superior or inferior since the innominate is not vertically displaced.

Diagnosis Based on the Innominate Sidebending Model

Physical findings of a superior or inferior sidebent innominate are similar to those found in conventional osteopathic examination. The patient is examined in all 4 testing positions (standing, seated, supine, and prone). The following findings will be found in all positions in cases of a *superior sidebent innominate:*

- Superior iliac crest on the involved side with positive standing flexion test
- Superior ASIS, PSIS, and ischial tuberosity on involved side

Likewise, the following findings will be found in all cases of an *inferior sidebent innominate:*

- Inferior iliac crest on the involved side with positive standing flexion test
- Inferior ASIS, PSIS, and ischial tuberosity on involved side

Note that the pubic tubercle is not examined as part of this model. The proximal pubic ramus will demonstrate inconsistent findings in innominate sidebending and therefore is not considered diagnostic.

Compression applied anterior to posterior on the involved innominate through the ASIS will demonstrate decreased motion of the innominate on the dysfunctional side. The standing flexion test would continue to be positive on the dysfunctional side. The patient may also experience discomfort at the ASIS and/or the sacroiliac joint on that side. In cases that have been present for longer periods of time (weeks to months) the patient may also demonstrate tightness of the ipsilateral psoas, hip adductors and hamstrings, and develop neuromuscular imbalance and back pain.

Treating Sidebent Innominate Dysfunctions

One of the classic high-velocity, low-amplitude (HVLA) treatments of an upslipped innominate is the supine traction tug. Interestingly, even though Mitchell's muscle energy model discusses the upslipped and downslipped innominate, the treatments presented are those of the HVLA traction tug.[11,12] Logic suggests that the traction tug would have the same effect of reducing the superior sidebent innominate dysfunction since it is bringing the affected innominate to its restriction barrier (eg, introducing as much inferior sidebending as the system will tolerate) and then adding a brief additional tug to the leg.

Based on the innominate sidebending model, we have developed a couple of simple muscle energy treatments. In Van Buskirk's clinical experience, these muscle energy treatments are always effective at restoring normal innominate position and function when either a superior or inferior sidebent innominate is the presenting diagnosis.

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To treat a patient who has a superior sidebent innominate:

1. The patient should be supine.
2. The leg on the affected innominate side should be adducted across the other leg, engaging the restriction at the superior sacroiliac joint *(Figure 2)*. The physician's hand may be placed against the lateral aspect of the thigh or knee on the affected side.
3. The patient should be instructed to push the leg laterally against the physician's resistance for 3 to 10 seconds.
4. After the patient's effort stops, the physician further adducts the affected leg. Repeat 2 more times.

Alternately for a superior sidebent innominate:

1. The patient should be lying on the nondysfunctional side at the edge of the table. The physician stands in front of the patient to help stabilize the patient.
2. The leg of the dysfunctional side is adducted with slight flexion at the hip to allow the upper leg to fall in front of the lower leg. Gravity will bring the leg and innominate into the restriction.
3. The physician places an operating hand on the lateral thigh of the affected innominate, and the patient is instructed to lift the leg toward the ceiling against the resistance of the physician's hand.
4. After the patient lifts for 3 to 10 seconds, the patient's effort is allowed to stop. Gravity and the physician's hand gently press the leg into further adduction. Repeat 2 more times.

For an inferior sidebent innominate:

1. The patient should be supine.
2. The physician brings the leg and innominate into abduction to the restriction as palpated at the inferior aspect of the sacroiliac joint (S3) *(Figure 3)*.
3. While the physician holds the leg in this position, the patient is instructed to push the leg on the restricted side toward their other leg for 3 to 10 seconds.
4. The physician then abducts the leg further into the restriction. Repeat 2 more times.

Still Technique Model

Based on the Still Technique model[13] of osteopathic treatment, treatment is divided into 3 parts:

1. Placing the innominate in its position of anatomic dysfunction.
2. Applying compression or traction from a distant attached portion of the anatomy. (In this case, the leg.)
3. Using the compression or traction force to carry the innominate into a position of anatomical correction.

To treat a superiorly displaced innominate using Still Technique:

1. With patient in the supine position, the ankle is grasped by the operator with both hands, and the lower extremity is placed in abduction. This will then bring the innominate into its ease position of superior sidebending *(Figure 4a, page 27)*.

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Figure 2. *Position for treating a right inferior sidebent innominate using muscle energy technique.*

Figure 3. *Position for treating a right superior sidebent innominate using muscle energy technique.*

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2. Light compression or traction is applied to the lower extremity towards the superior part of the SI joint.
3. Maintaining this compression or traction, the lower extremity is then moved across midline into adduction *(Figure 4b)*.

To treat an inferiorly displaced innominate:

1. With patient in the supine position, the ankle is grasped by the operator with both hands, and the lower extremity is placed in adduction *(Figure 5a)*.
2. Light compression or traction is applied to the lower extremity toward the inferior aspect of the SI joint.
3. Maintaining this compression or traction, the lower extremity is then moved across midline into abduction *(Figure 5b)*.

For both sets of treatments, the patient is then reevaluated in the supine and standing positions to assure that the pelvis has been returned to the level position and that the standing flexion test is negative.

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Figure 4a. *Starting Position for treating a left superior sidebent innominate using Still Technique.*

Figure 4b. *Ending position for treating a left superior sidebent innominate using Still Technique.*

Figure 5a. *Starting position for treating a right inferior sidebent innominate using Still Technique.*

Figure 5b. *Ending Positon for treating a right inferior sidebent innominate using Still Technique.*

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Treating Combined Innominate Dysfunctions

In cases of extreme pelvis obliquity that is not due to underlying scoliosis or leg length difference, patients may have sidebending dysfunctions of *both* innominates (superior sidebending on 1 side and inferior sidebending on the other side). This is often due to a stumbling injury or fall where 1 leg is placed in marked abduction or external rotation and the other leg is placed into marked adduction or internal rotation. This scenario often results in severe low back pain, frequently radiating into both buttocks or lower extremities. The apparent leg length discrepancy with the patient supine will typically be in excess of 18 mm (0.625 inch).

The primary dysfunction is the 1 found with the initial positive standing flexion test, and should be treated first. Combined innominate dysfunctions will result in a *positive standing flexion test on the opposite side* once 1 side of the pelvis is treated and reevaluated. Once the second dysfunction is treated, the pelvis will be found to be level and the patient will have a negative standing flexion test. Oftentimes, sacral motion dysfunction will be present with combined innominate dysfunctions and will need to be treated as well.

Need for Research Verification of this New Model

All new theories need to be tested and proven by scientific research. External body measurements are very difficult to reproduce accurately, and we welcome further research and ideas on how to accurately measure innominate motion relative to the lumbar spine and sacrum. Whether or not this new model stands the tests of time and future research, we find that this new treatment approach offers an easier, less traumatic approach to treating what have been traditionally termed superior and inferior innominate shears.

Conclusion

New research on low back pain and sacroiliac motion and stability coupled with clinical findings necessitates a rethinking of somatic dysfunctions that have been traditionally termed superior and inferior innominate shears. The authors propose a new model of innominate motion dysfunction based on sidebending of the innominate at the sacroiliac joint rather than a shearing motion along the long axis of the sacroiliac joint. Even though clinical experience supports this new model, future research designed to accurately measure innominate motion relative to the sacrum and spine is indicated to assess the accuracy of this new model of innominate motion dysfunction.

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