Asia-Pacific Chiropractic Journal

Is the sacrum a keystone or is it suspended?

Rick Serola

Introduction: Whether the sacrum functions as keystone or is suspended from the ilia has been debated for well over one hundred years. In the early 1990s Vleeming and Stoeckart (1) and, separately, Snijders, (2) published their findings that the sacrum fits into a receptacle like a keystone in a Roman Arch. Vleeming stated '*the bone (sacrum) is wider cranially than caudally and wider anteriorly than posteriorly. Such a configuration permits the sacrum to become "wedged" cranially and dorsally into the ilia within the pelvic ring.*'

DeJarnette (3) stated '*The sacrum is wedge-shape from above downward, its base articulating with the fifth lumbar vertebra; it is also wedge-shaped from backward, a fact that makes clear the statement that the sacrum is held suspended between the innominates by strong ligaments instead of completing the bony girdle as the keystone caps the arch*.'

The question that arises is how can both authors give the same description of the sacrum and its relationship to the ilia and come to opposite conclusions of their function? Is the sacrum a keystone or is it suspended?

Methods: Review of published articles explaining Vleeming's Stockert's and Snijders' view of the Keystone Form & Force Closure and DeJarnette's view of the suspended sacrum, with support from other authors.

Discussion: Vleeming, et al (1) proposed that at the end of range of motion, the sacral and iliac articular surfaces would be compressed together, and load transmission would occur directly between the sacrum and ilia by '*bone contact force*' at the articular regions.

Snijders (2) also asserts that weight transfer is through the articular facets of the SIJ. Claiming that the SIJ articular surfaces are flat, he drew force vectors that supposedly intersected at the SIJ to provide a '*self-bracing effect*' on a flat SIJ. Although he briefly mentioned that the SIJ surfaces were propeller shaped, he attributes that to counteracting flexion and then ignores the actual shape of the facets, and continues as if they were flat.

Vleeming et al (4) referenced Solonen (5) in stating that the sacrum is shaped like a keystone, but omitted his statement that the sacrum hangs down from the ilia by its dorsal ligaments.

Further, other researchers who said that the sacrum is suspended by ligaments include DonTigny, (6) Kapandji, (7) and Levin (8) who makes an excellent description of the suspension of the sacrum within three-dimensional space by comparing it to the hub of a wheel suspended by spokes, '*in contrast to the keystone and similar models*.'

The main difference between the two concepts of a keystone and suspension is how force transfers between the sacrum and ilia. The keystone principle is that force transfers from bone to bone (with intervening cartilage) through the articular facets. Conversely, a suspended sacrum transfers force through the syndesmosis by the ligaments, more like a hammock or a hub of a wheel. Instead of force pushing one bone into the other, placing the weight of

the entire upper body at two relatively small points, the force pulls one bone towards the other; in this manner, force transfers from ligament to bone to ligament to bone etc., where stability is shared by the entire kinematic chain.

Vleeming, et al. and Snijders considered weight bearing to go through the articular facets, but have no study to support their concept. Conversely, Cusi (9) stated that '*The utility of SPECT/CT for the diagnosis of SIJ dysfunction and more specifically the failure of load transmission across the joint is confirmed in the current study … the vertical loads mainly go through the posterior and interosseous ligaments.*'

To further support ligamentous suspension, Vukicevic et al ,(10) using holographic analysis, applied a wide range of loads to 12 cadaveric pelvises with preserved lumbar spines, hip joints, and ligaments.They found that '*tight contact between the articular surfaces is never reached in a wide range of the applied loads, secured by strong sacroiliac interosseous ligaments.*'

Vleeming states that the configuration of the sacrum and ilia permits the sacrum to become '*wedged*' cranially and dorsally into the ilia (counternutation), and notes that this '*keystone-like boney architecture of the sacrum further contributes to its stability within the pelvic ring.'* Apparently, the vertical position of the sacrum positions the facets to slide inferiorly into the receptacle formed by the ilia, as in a keystone.

In other words, he described counternutation, in which the sacrum is more vertical, as being the position of stability during force transfer but he also recognises that '*in self-bracing of the pelvis, nutation of the sacrum is crucial*' in which the sacrum is more horizontal. The contradiction is evident, but not immediately recognised. What is missing in the keystone concept is the mechanism that provides stability for weight transfer during nutation.

In accordance with DeJarnette, it should be noted that, during nutation, the anterior-posterior shape of the sacral base demonstrates a requirement for the sacrum to drop anteriorly and inferiorly away from the ilia during weight bearing into a more horizontal position. In this situation, the anatomical function of the large mass of ligaments suspending the sacrum from the ilia becomes evident; the only structure holding the sacrum and ilia together are the strong sacroiliac ligaments.

Conclusion: Keystone proponent's claim that both counternutation and nutation are necessary positions of stability for force transfer through the sacroiliac joint are contradictory statements.

While the weight of the upper body drives the sacrum into nutation, no mechanism has been explained that drives the sacrum into counternutation. Since forces occurring during load transfer force the sacrum anteriorly and inferiorly into nutation, there is no practical need for the sacrum to be '*wedged*' dorsally. To speak of wedging the sacrum dorsally is misleading and only serves as a distraction from considering true anatomical form and function.

DeJarnette's description of sacral suspension is consistent and makes biomechanical sense. Stability is needed during nutation when the weight of the entire upper body is transferred to the sacrum, where force is absorbed, and range of motion is limited by the ligaments.

Indexing terms: Chiropractic; DeJarnette; sacrum; sacral biomechanics; keystone.

Rick Serola
DC
Private Practice, Loves Park, IL
rick@serola.net

Cite: Serola R. Is the sacrum a keystone or is it suspended? [Abstract]. Asia-Pac Chiropr J. 2022;3.1 URL apcj.net/SOT-Abstracts-2022/#SerolaSacrumKeystone

References

1. Vleeming A, Stoeckart R. The role of the pelvic girdle in coupling the spine and the legs: a clinical-anatomical perspective on pelvic stability, in Movement, Stability, & Lumbopelvic Pain, A. Vleeming, D. Mooney, and R. Stoeckart, Editors. 2007, Churchill Livingstone Elsevier. 229-237.

2. Snijders, C.J., Transfer of Lumbosacral Load to Iliac Bones and Legs: Part 1 - Biomechanics of Self-Bracing of the Sacroiliac Joints and its Significance for Treatment and Exercise. Clinical Biomechanics. 1993a; 8:285-294.

3. DeJarnette MB. Sacro Iliac Technic. Privately Published: Nebraska City, NB.1938.

4. 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 Dec;221(6):537-67.

5. Solonen KA. The sacroiliac joint in the light of anatomical, roentgenological and clinical studies. Acta Orthop Scand Suppl.1957;27:1-127.

6. DonTigny RL. Function and pathomechanics of the sacroiliac joint. A review. Physical Therapy. 1985;65(1):35-44.

7. Snijders CJ. Transfer of Lumbosacral Load to Iliac Bones and Legs: Part 2 - Loading of the Sacroiliac Joints when Lifting in a Stooped Position. Clinical Biomechanics. 1993b; 8:295-301.

8. Levin SM. The Sacrum in Three-Dimensional Space. Spine: State of the Art Reviews, 1995;9(2): 381-88.

9. Cusi M. SPECT-CT on patients with a clinical diagnosis of failure of load transfer of the sacro-iliac joint. Proceedings of the 7th Interdisciplinary World Congress on Low Back & Pelvic Pain. 2010. Los Angeles.

10. Vukicević S, Marusić A, Stavljenić A, Vujicić G, Skavić J, Vukicević D. Holographic analysis of the human pelvis. Spine (Phila Pa 1976). 1991 Feb;16(2):209-14.