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A Review of the Sacroiliac Joint

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A REVIEW OF THE SACROILIAC JOINT

by

Mark Daugherity
Bachelor of Science in Physical Therapy
University of North Dakota, 1993

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
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This Independent Study, submitted by Mark Daugherity in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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Title  A Review of the Sacroiliac Joint

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ABSTRACT

Low back pain is one of the leading causes of lost productivity at work and disability in the United States. There are many factors thought to be involved in this diagnosis. These include intervertebral disc problems, mechanical dysfunctions, muscle sprains, ligament strains, and infectious diseases, such as rheumatoid arthritis and tuberculosis. One area often overlooked in the diagnosis of low back pain is the sacroiliac joint. There is much controversy surrounding the function of this joint. Although some clinicians question if there is any movement at all, many manual therapists evaluate this area in their daily practice and believe that appreciable motion does exist. Because of its orientation, the sacroiliac joint is difficult to visualize clearly with radiographic techniques. This increases the difficulty of diagnosing pathology in this area. However, with careful clinical testing procedures performed by experienced therapists, many believe they can isolate sacroiliac dysfunction.

The purpose of this study is to describe pathological conditions of the sacroiliac joint. The procedure used will be a literature review to include the anatomy, function, and motion, and will attempt to explain some diagnostic
procedures used to confirm dysfunction at this joint. The results will be useful for physical therapy clinicians in diagnosing and treating sacroiliac dysfunction.
CHAPTER I

INTRODUCTION

Pain in the low back has been diagnosed and misdiagnosed, treated and mistreated for decades. Despite applying recent advances in research and technology, taking proper histories, and performing thorough examinations, a high percentage of patients with pain in the low back have no identifiable pathology. The most frequent causes of low back pain are muscle and ligament strains, disc disease, and arthritis, but the differential diagnosis can be complicated. An area that is often overlooked as a source of low back pain is involvement of the sacroiliac joint.

The sacroiliac (SI) joint has been the topic of much debate, speculation, and controversy. Osteopaths, obstetricians, and physical therapists place a great deal more importance on it as a source of low back pain than do physicians. Medical practitioners are skeptical about manipulative therapy in general and associate it only with chiropractic diagnosis and therapy; the orthopedic literature has traditionally taught that the SI joints do not move and therefore should not be considered a source of pain; and low back pain is a problem that lies outside most obstetricians’ area of expertise.
To date, methods of investigation of the SI joint have included using cadavers and living subjects. Measurement techniques have varied from sophisticated X-ray to clinical palpation. Some have ignored the joint, denying both function and dysfunction, and some have made an honest effort toward thorough assessment. The morphology of the joint makes assessment of motion somewhat difficult. However, manual therapists and other health care workers are increasingly focusing their attention on the SI joint as a cause of low back pain.

The purpose of this study is to describe pathological conditions of the SI joint. The procedure used will be a literature review to include the anatomy, function, and motion, and will attempt to explain some diagnostic procedures used to confirm dysfunction at this joint.
CHAPTER II
ANATOMY

The bony pelvis constitutes the base of the trunk, supporting the superincumbent body structure and linking the vertebral column to the lower extremities.¹ The pelvis is made up of three bones, the paired innominates and the intervening sacrum. It is also composed of three joints, the two sacroiliac (SI) joints and the symphysis pubis.

The innominate bone consists of three segments: the ilium, ischium, and pubis. The ilium is the portion of the innominate that articulates with the sacrum to form the SI joint, thus the terms iliosacral and sacroiliac are appropriate anatomical terms for this joint.²

The sacrum is a mass of irregularly shaped bone formed by the fusion of the five sacral vertebrae. It is a double wedge, tapering from anterior to posterior and from cephalad to caudad, with convex auricular sides that fit tightly into matching concavities in the ilia.³ The sacrum, firmly entrapped between the innominates and suspended from the ilia, carries the weight of the spine.³

The SI joints are among the strongest in the human body.⁴ Solonen⁵ found that approximately 87% of the articular surface of the SI joint is formed
by the first, second, and third sacral segments. These joints possess a synovial membrane and are surrounded by large ligaments which bind the pelvic ring into a stable, weight-bearing structure. The size, shape, and contour of the SI joint vary considerably from person to person and even from side to side in the same person. The joint is usually described as "L-shaped" when viewed from the side, with the long arm directed caudally and the short arm cranially. The concave sacral surface is longer and narrower than that of the ilium. The iliac surface is convex and reciprocally shaped, but not exactly congruent with the sacral surface.

According to Lynch, Albinus and Hunter were the first to demonstrate that the SI articulations were true joints possessing synovial membranes. Schuchmann and Cannon stated that the SI joints are among the strongest and most stable diarthrodial joints of the human body. Others have described the SI joints as amphiarthrodial, an intermediary between a synarthrosis and diarthrosis, and diarthroamphiarthrodial. Walker described the joints as part synovial and part syndesmosis, not amphiarthrodial. Grieve stated that the interosseous SI ligament converted the joint into part syndesmosis. Sashin concluded that the SI joints are diarthrodial until the mid-adult years, and then motion progressively decreases. Differences in SI joint classification may stem from the type of articular cartilage found. Several authors report the sacral articular cartilage to be hyaline and the iliac cartilage to be fibrous.
The greater thickness of the sacral cartilage compared with the iliac cartilage has been consistently reported. Pacquin and colleagues\textsuperscript{15} showed a 2:1 greater thickness of the sacral cartilage compared with the iliac cartilage. Porterfield and DeRosa\textsuperscript{2} state that the sacral hyaline cartilage is 1.7 to 5 times thicker than the fibrocartilage that lines the iliac surface. As these two components articulate and become compressed, cartilage deformation results. This accommodation by the cartilage is one method of force attenuation by the SI joint as trunk and ground forces converge into the region.\textsuperscript{2} The variability in composition and thickness of the joint surfaces may result in earlier and greater wear of the iliac surface.\textsuperscript{11}

Gender differences become evident by 12 to 14 years of age as the male SI ligaments begin to increase in strength, while the female joints become more mobile.\textsuperscript{16} In the adult female, the sacrum is shorter and wider with a ventral concavity that is deeper. Women tend to have a shorter, broader pelvis with more laterally oblique ilia resulting in a greater valgus angulation of the lower extremity.\textsuperscript{1} The shape and mobility of the female pelvis facilitates parturition\textsuperscript{(1)} and may subject women to greater torsional and shear stresses during and immediately following pregnancy. Pelvic mobility also increases during menstruation due to hormonal changes.\textsuperscript{17} In men, the pelvis tends to be less flared, with the ilia more vertical and a more narrow sacral base.\textsuperscript{1} The sacral articular surface is shorter in females, but for both males and females, it usually
extends along the sides of S₁ to S₃. The auricular surfaces in females are also smoother than in males.

The contour of the sacral and iliac articular surfaces has been the subject of several studies. Solonen described the joint surfaces as asymmetrical in size, shape, and direction, and reported that the surfaces lie on numerous planes. He also found the articular surfaces to contain numerous depressions, elevations, and irregularities, concluding that sacral motion could only be slight and irregular. Weisl found the sacral surface to consist of two main elevations, one lateral to the first sacral vertebrae and a less prominent caudal one. In young subjects, the two elevations were separated by a saddle-shaped depression. The dorsal aspect of the auricular surface is hollowed out posterior to the elevations, forming a groove for the longitudinal ridge, which characterizes the iliac surface. The variability and complexity of the orientation of the joint surfaces are factors that contribute to the unique stability of the SI joint.

Although adhesion formation and loss of the SI joint synovial cavity has been reported in both genders, some morphological and histological studies have demonstrated higher frequencies of joint surface irregularities and apparent pathological changes in male specimens. Resnick and associates revealed para-articular bony ankylosis resulting from bridging osteophytes and focal cartilaginous fusions. Sashin reported more osteoarthritic changes in male specimens than in female specimens. Vleeming and coworkers stated
that these changes may reflect a normal response to greater imposed forces in
the SI joints of men compared with women. It must be noted that the material
studied was derived from postmortem and cadaver specimens and therefore
may not be representative of the general population.

There is general agreement that joint surface irregularities increase with
age. In the third and fourth decades, there is an increase in the number and
size of the elevations and depressions. The main effect of this arrangement is
to gain stability at the expense of mobility. Bowen and Cassidy reported that
differences in the two surfaces are present throughout life, with the iliac surface
showing earlier and more extensive degenerative changes. With Vernier
calipers, Weisl measured the height of the surface irregularities of articular
cartilage of both surfaces of the SI joint. He concluded that with aging,
interlocking between surface elevations and depressions could occur, with
ankylosis commencing after 30 years of age. Volger and colleagues reported
that asymmetry in subjects over 30 years of age may indicate abnormality.
However, the frequency with which elevations are observed on the SI joint
surfaces has led some investigators to conclude that these changes are normal
age-related changes, reflecting the stresses and strains to which the joint is
exposed, and are not pathological. In the elderly, the joint cavity is partly
obliterated by fibrous or fibrocartilaginous adhesions.

The ligaments supporting the pelvis are strong, well-developed, and
contribute significantly to overall stability. The SI ligaments have been
classified as capsular and accessory ligaments. The ventral, interosseous, and dorsal ligaments are the capsular ligaments, and they play an important role in maintaining the integrity of the SI joint. The ventral ligaments run from the pelvic surface of the sacrum to the wing of the ilium and are a thickening of the joint capsule. These ligaments may resist anterior movement of the sacral promontory. The interosseous ligament is often described as the strongest ligament in the body, principally responsible for the stability of the joint. This ligament forms the chief bond between the sacrum and ilia and has cranial and caudal bands. It is the primary restraint to excessive SI movement. The dorsal ligaments are extremely thick and stronger than the ventral ligaments. The interosseous and dorsal SI ligaments resist separation of the iliac wings. They may also resist forward bending. Backward bending is limited by tension of both the ventral and dorsal SI ligaments.

The sacrotuberous, sacrospinous, and iliolumbar ligaments are the accessory ligaments. The sacrotuberous ligament originates on the lower sacrum and upper portion of the coccyx, and runs an oblique course inferiorly to its insertion on the ischial tuberosity. The sacrospinous ligament courses superiorly, medially, and posteriorly from the ischial spine to a broad insertion on the sacrum and coccyx. The function of both of these ligaments becomes evident in weight-bearing positions as they act to check the forward flexion moment of the sacrum on the innominate as trunk forces converge on the sacrum. They hold the inferior sacrum close to the posterior pelvis to
counteract the rotational force or torque created by the body weight. They also minimize the potential for one ilium to rotate posteriorly on the sacrum. Forward rotation or nodding of the sacrum is limited by tension of the sacrotuberous, sacrospinous, and ventral SI ligaments.

The iliolumbar ligaments originate from the transverse process of the fifth lumbar vertebra and insert on the iliac crest. Although the iliolumbar ligaments do not directly stabilize the SI joints, they play an important part in iliolumbar and lumbosacral mechanics. These ligaments are well-developed and primarily provide a mechanism by which anterior shear of the fifth lumbar vertebra is prevented. They also have the role of stabilizing the lumbosacral junction in all directions, especially in lateral bending. Separation of the iliac bones during movement is resisted by the SI and iliolumbar ligaments as well as by the ligaments of the symphysis pubis.

Although some of the largest and most powerful muscles in the body surround the joint, according to CassidY, none are known to directly influence its movement. However, AlderinK reported that even though there is only one muscle, the piriformis, with a direct attachment to the sacrum, it is evident that many trunk and lower extremity muscles may exert a profound influence on SI joint mechanics. Porterfield and Oerosu describe several trunk and lower extremity muscles that could directly or indirectly influence pelvic motion. The abdominal muscles, erector spinae, and quadratus lumborum provide three-dimensional pelvic and lumbar stability as they effectively transfer and absorb
gravitational and body weight forces. The tensor fascia latae and other hip abductors provide for pelvic stability in the frontal plane but can also affect innominate motion directly. The hip extensors provide for sagittal plane pelvic stability and may indirectly influence sacral motion via their attachments to the sacrotuberous ligament. The rectus femoris and sartorius can directly produce iliosacral movements in addition to their actions at the hip and knee. The hip adductors influence pelvic motion in general, but acting unilaterally, they may affect motion at the symphysis pubis. In addition, Walker states that the adjacent muscles; i.e., the quadratus lumborum, erector spinae, gluteus maximus, gluteus minimus, piriformis, iliac muscles, and even the more distantly located latissimus dorsi muscle, all have fibrous expansions that blend with the anterior and posterior SI ligaments and contribute to the strength of the joint capsule, and thus to the joint's stability.
CHAPTER III
FUNCTION

Gray’s Anatomy\textsuperscript{27} states that the function of the SI joints is to lessen concussion in rapid changes of distribution of body weight in each of two directions. They act like shock absorbers and, in doing so, they undergo some rotation through a transverse axis. One component of the force is expended in driving the sacrum downward and backward and is resisted by the wedge shape of the sacrum and the SI and iliolumbar ligaments.\textsuperscript{28} The second component of force produces a rotatory movement by which the superior end of the sacral articulation is tilted down and the inferior part tilted up. It is also resisted by the wedge form and the SI, sacrotuberous, and sacrospinous ligaments.\textsuperscript{28}

The SI joint appears to have another and probably more important role in ambulation.\textsuperscript{3} Ambulation can be considered as a controlled fall with a forward inclination of the trunk to initiate and continue forward movement (inertial moment), while the legs move forward alternately to maintain balance. A braking force (deceleration moment) is created on initial heel strike. Between the inertial moment of the upper trunk and the deceleration moment on the
innominates is a margin of shear. The SI joints function to absorb the shearing forces.\textsuperscript{3}

Hypotheses about SI joint function have developed as the result of attempts to explain clinical problems and their resolutions. Researchers have not been able to agree on a single model of SI function. They are aware that the SI joint may function during open-chain and closed-chain activities, and that it may respond differently under those two circumstances.\textsuperscript{19}
CHAPTER IV
MOTION

Motion at the SI joint is often identified by the type of movement at the adjacent joints responsible for producing SI joint motion. The sacrum is influenced by movements that direct trunk forces to it from above through the lumbar spine.\(^2\) In upright standing, the weight line courses down through the bodies of the lumbar vertebrae and onto the sacrum. The effect of this weight line causes forward flexion of the sacrum. Thus, the sacrum is oriented within the pelvis in a kyphotic and relatively flexed position. Lumbar movement produces motion of the sacrum on the ilium, or sacroiliac (SI) motion.

The innominate bones are governed by ground forces that reach them by way of the lower extremities through the hip joint.\(^2\) Leg movement produces motion of the ilia on the sacrum, or iliosacral motion. Symmetric trunk or leg motion appears to be accompanied by symmetric ilial motion and sacral nutation (flexion) or counternutation (extension); whereas, asymmetric trunk or leg motion is accompanied by asymmetric ilial motion and some combination of side bending, rotation, and forward/backward bending of the sacrum.\(^29\)

The premise that the SI joint can be a locus of low back pain rests on the assumption that this joint is capable of motion.\(^11\) In recent years, it has been
generally recognized that these joints do indeed have the potential for motion. Motion at the joint has been characterized as angular; that is, a combination of both rotatory and translatory motion. Therefore, motion values are reported in both degrees and millimeters (mm).

Motion at the SI joint has been investigated by using both living subjects and cadaveric material in descriptive and analytical studies.

Descriptive studies measure the distance between pelvic landmarks on the ilia and sacrum. If a change in body position results in an increase or decrease in the distance between landmarks, an inference is made that the relative position of the pelvic bones has changed because of SI joint motion. Ashmore was one of the first to report quantitative data on motion of the SI joint. She measured a difference in the distance between the posterior superior iliac spines (PSISs) as a function of body position. The distance was observed to be greater in the upright standing position as compared with the forward bent position. This difference was cited as evidence of SI joint movement. Colachis placed Kirschner pins in the PSISs of his subjects and measured the difference in the distance between them in nine different positions. He observed that the greatest motion was in forward bending from the standing position.

Miller and colleagues measured the load-displacement behavior of both single and paired SI joints in fresh adult cadaver specimens. Test loads were applied at the center of the sacrum along two mutually perpendicular axes, first
with both ilia fixed and then with one ilium fixed. When both ilia were fixed, the motions were small, with 0.5 mm of translation and 1.9 degrees of rotation being the greatest values reported. With only one ilium fixed, the average measurement for rotation ranged from 2 to 7.8 times the values measured previously, while translations increased threefold. However, the authors conceded that fixing both ilia did not represent in vivo conditions.

The primary objective of analytical studies is to identify an axis of rotation that describes the motion of the SI joint. Investigators of SI joint mobility generally have focused on two main questions: 1) what is the extent of movement, and 2) what is (are) the axis(es) of motion? There is no agreement in the literature for a single model of SI joint motion, or on a single fixed axis of motion, but rather agreement on the variability of both. For example, Weisl placed the rotational axis 5 to 10 cm vertically below the sacral promontory, but also stated that the sacrum underwent a pure linear displacement along an axis on the caudal portion of the articular facet. Kapandji reported a potential axis at Bonnaire’s tubercle, which is a bony prominence between the cranial and caudal segments of the sacral articular surface. This would cause a rotatory motion of the ilium on the sacrum since the horizontal axis runs through the joint itself. Lavignolle and associates calculated the horizontal axis of the SI joint to exist just posterior to the pubic symphysis. This would suggest more of a shearing stress which would
essentially be a type of upward or downward "sliding" of the ilium on the sacrum.

Mitchell and co-workers\textsuperscript{34} have hypothesized that the sacrum rotates relative to the ilium about a diagonal axis. A diagonal axis is created by the contraction of one of the piriformis muscles. For instance, when the left piriformis muscle contracts, it pulls the sacrum obliquely downward against the left lower pole of the SI joint. Secure in that position, there is a pivot point at the lower left pole and a right diagonal axis is created.\textsuperscript{34} During ambulation, the ilium appears to rotate posteriorly during the swing phase and converts to an anterior rotation soon after the loading response, achieving a maximum position at terminal stance. The sacrum appears to rotate forward about the diagonal axis during the loading response, reaching its maximum position at midstance and begins to reverse itself during terminal stance. Alderink\textsuperscript{19} suggests that intrapelvic motion during ambulation is necessary to help dampen the axial, torsional, and shear stresses.

A number of X-ray studies have been conducted to attempt to demonstrate SI joint movement. Simkins\textsuperscript{35} made the assumption that sacral movement consists of rotation in the sagittal plane about a transverse axis located at the junction of the second and third sacral segments. He compared lateral X-rays of his subjects in the flexed and extended positions by erecting vertical and horizontal coordinates at the transverse axis. He reported a range of sacral motion from 4 to 12 degrees, with the average being 8 degrees.
Reynolds\textsuperscript{36} used stereoradiography to measure the displacements of the femur, innominate bone, and sacrum in a male cadaver. The cadaver was held in an upright position while the left hip (with knee extended) was moved into maximum flexion, then abduction, and finally abductoflexion (a combination of abduction and flexion. He found that the sacrum rotated about axes that were not oriented according to conventional cardinal planes, and these axes changed direction with changes in femoral position. Sacral rotations were small in comparison to the hip joint, but both joints displayed translations similar in magnitude.

Sturesson and colleagues\textsuperscript{37} inserted tantalum balls percutaneously over the ilium and sacrum and used roentgen stereophotogrammetry to measure "physiological end range" in 26 subjects in various physiological positions. The mean maximum mobility between endpoints was 2.5 degrees with a mean translation of 0.7 mm. However, they were unable to distinguish between subjects with and without SI joint symptoms. Therefore, they concluded that assessment of mobility under physiological loads could not be used successfully to identify SI joint dysfunction.

No other human joint, healthy or pathological, is characterized by the intra-articular elevations and depressions associated with the SI joint. Considering the various studies cited previously on the orientation of the articular surfaces, Wilder\textsuperscript{38} used topography and theoretical modeling, along with best-fit axes of rotation (AORs) for each contour, to calculate optimal axes
of rotation. Data were obtained from eleven hemipelvises. They concluded that motion could not occur exclusively around optimized AORs (axes proposed by other authors) in the sagittal and frontal planes. They stated that the position of the rotational axis varied considerably between individual specimens, most likely secondary to joint contour and soft tissue differences. They also stated that any rotation at the SI joint must be accompanied by a translation. These researchers suggest that a translatory motion could occur around a "rough axis" if some separation of the joint surfaces was present. The theorized required separation was a mean of 7.25 mm in the sagittal plane and 3.4 mm in the frontal plane. Based on his radiographic and cartographic studies, Weis18 reached a similar conclusion. He postulated that surface morphology, degree of congruence between the sacrum and ilia, and compressibility of the articular cartilage accounted for the variation in the position of the axes.

Rather than considering actual movement of the SI joint, one pair of researchers suggested that it is more logical to consider the moments that are developed around various axes. In addition to the ground and trunk forces, these moments are generated by some of the most powerful muscles in the body by virtue of their attachments to the pelvis. They propose that it makes more sense to consider the resultant forces as a moment that the joint is well designed to accommodate rather than movement of the two bones.
Sacral motion has been thought to occur with respiration with the top of the sacrum rotating backward in the sagittal plane with inhalation and forward with exhalation. However, it has been questioned whether the forces generated by respiration are sufficient enough to deform the ligamentous restraints of the sacrum or whether the entire pelvis flexes and extends.

Variations in SI joint movement have also been related to age and sex. After the third decade, the potential for appreciable motion appears severely limited. The loss of SI joint mobility occurs earlier in males, at ages of 40 to 50 years old. Similar changes are not found in the female until the end of the fifth decade.

Anatomical studies suggest that available motion may be greatest in women, during and immediately following pregnancy. During labor, the hips are relatively extended, placing a traction force on the hip flexor muscles. This results in an anterior pelvic tilt and simultaneous counternutation (extension) of the sacrum, favoring descent of the fetus into a wider pelvis. As the hips are flexed, abducted, and externally rotated during delivery, hamstring tension posteriorly rotates the pelvis relative to the sacrum (sacral nutation or flexion). The result is an increase in the pelvic outlet, favoring delivery of the baby.

Under normal conditions, the pelvic ligaments are designed to prevent excessive or abnormal movement. However, during pregnancy, there is a selective laxity which is noted at the SI joint. The hormone relaxin, probably in
combination with other biochemical changes, appears to alter the stiffness of the connective tissue to allow for the expansion of the pelvic outlet during childbirth. This starts at the fourth month and lasts for 3 to 5 months postpartum.

In summary, investigators of the SI joint have described sacral motion characterized by flexion, extension, rotation, and upward and downward gliding in relation to the ilia. Movements have been observed to be rotatory, transulatory, or a combination of the two. The fact that SI joint movements are small is fairly well accepted. The controversial aspect is related to the significance of this small amount of motion. Many therapists agree that motion must occur both to create SI joint dysfunction and, most importantly, to substantiate manual therapy procedures designed to relieve symptoms and restore function.
CHAPTER V

PATHOLOGY

The role of the SI joints in body mechanics can be illustrated by a mechanical analogy. A 1 to 2 mm malalignment of a bearing in a machine can cause abnormal wear or a breakdown in function, not only of the bearing and adjacent parts, but also of parts remotely related to it through the creation of abnormal forces. Joints in the body are subject to similar types of dysfunction, which also may have local or remote effects.

Sacroiliac dysfunctions may either be primary or secondary in origin. Primary dysfunction occurs as a result of trauma, such as blows or falls on the buttocks, or childbirth. Secondary dysfunction comes on slowly and is usually compensatory to scoliosis, disease, cases of leg length inequality, or maladaptations of the pelvis to extrinsic forces during gait. When trunk and ground forces reach the pelvis, they must be attenuated by the SI joints and supporting tissues. The applied stresses must be within the limits of physiologic tolerances. When these stresses exceed the normal physiologic capacity of the tissues, an injury with a resultant painful condition can develop.

The SI joint has been implicated as a factor in low back pain as far back as the turn of the century, but after the 1930s interest shifted to the
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intervertebral disc. With SI joint dysfunction, subjective symptoms may not appear for several weeks or even months. When they do appear, symptoms include pain located in the affected joint, referred pain simulating sciatica, a constant feeling of weakness or fatigue in the lumbosacral region, and difficulty turning over when lying on one's side. Clinically, the SI joint can give rise to pain in the gluteal region and leg, which is often difficult to differentiate from other causes of low back pain.

In most cases, the SI joint remains patent throughout life. However, one constant and unique feature of the joint is the tendency for the iliac fibrocartilage to degenerate early in life. It is common to observe early signs of iliac osteoarthritis by the third decade of life in males and 10 to 20 years later in females. Large crevice formation and surface erosions can also be present and tend to occur more frequently in middle-aged males. Bony ankylosis is rare, but para-articular synostosis has been reported as a common finding in specimens of both sexes over the age of 50 years. Similar changes on the sacral side are not observed until later in life.

The position commonly associated with the onset of low back pain is trunk flexion. Activities such as working over a counter, making a bed, shaving, and washing dishes shift the weight of the trunk over the anterior pelvis. If anterior pelvic support from the abdominal muscles is adequate, there is no problem. However, if support from the abdominals is not adequate, the anterior pelvis rotates downward around the acetabula. This anterior rotational force tends to
rotate the innominate bones anteriorly on the sacrum. Since the sacrum is placed within the innominates and is wider anteriorly than posteriorly, the innominate bones spread on the sacrum. On reaching the limit of their motion, they wedge and lock. Fixation of the SI joints prevents function, and forces previously expended in the joint are transmitted to the intervertebral disc. This may be a significant factor in herniation of the disc.

Sacroiliac joint dysfunction is commonly due to hypermobility, which often results in a positional fault. The most common positional fault occurs when one ilium rotates either in a forward or backward direction on the sacrum, and may often occur in conjunction with a sacral positional fault and/or a positional fault at the symphysis pubis. Any position that takes the pelvic joints to their end range, such as full forward or backward bending combined with sidebending or moments applied to the hip joint that is already at end range, renders the area vulnerable to injury. If the limits of SI joint motion are reached, and then a force is imparted through the lower extremities from below or through the trunk from above, there is a potential for sprain or strain to the various supporting tissues.

Since sacroiliac sprain syndrome is not a common disorder, it may be overlooked as a cause of low back pain. The syndrome is characterized by the acute onset of pain during torsional strain, tenderness over the affected joint, and relief of symptoms by infiltration of the joint with a local anesthetic. Low back pain in the distribution of the lumbar and thoracolumbar paravertebral
musculature, pain in the gluteal region, pain in the muscles of the upper leg, knee pain, hip pain, and even cephalgia or neck pain are examples of musculoskeletal complaints traced to SI sprain. The distribution of pain is not consistent with a nerve root compression or radiculopathy.

Certain situations increase the risk of straining the SI joints. During pregnancy, mechanical and hormonal factors contribute to the increase in pelvic joint mobility sometimes resulting in a painful subluxation. Young cites radiographic evidence of a widening of the SI joints in pregnant women compared to nonpregnant women. The gravid uterus and the weight gain of pregnancy causes an increase in lumbar lordosis and stress on the lumbar spine and pelvis. Release of the hormone relaxin softens the rigid ligaments of the SI joints and symphysis pubis to facilitate passage of the fetus through the pelvis. This softening of the pelvic ligaments, combined with the stress of postural changes to accommodate the increased anterior weight of the fetus, makes these areas prone to injury and may allow subluxation of the SI joints. The pain of SI subluxation affects many women during the second trimester of pregnancy, potentially preventing these women from continuing work or preforming household responsibilities for a significant part of their pregnancies.

Some people believe that differences in muscle length may cause SI joint dysfunction. Cibulka reported a case study in which postures frequently assumed by his patient may have led to the development of asymmetrical muscle lengths of the hip rotator muscles. Habitual positions that placed the
hip in extreme lateral rotation, identified as sitting cross-legged and sleeping prone, may have contributed to the asymmetrical hip rotation by shortening the lateral rotator muscles and lengthening the medial rotator muscles. Presumably, shortened lateral hip rotators on the right side can posteriorly rotate the right innominate bone, resulting in a concomitant anterior rotation of the left innominate bone. Antagonistic innominate bone rotations can manifest as SI joint dysfunctions.⁴⁴

Differences in leg length has also been suggested as a cause of SI joint dysfunction.⁴⁴ When there is a leg length discrepancy or any other frontal plane asymmetry, the pelvis is lower on one side. Ground reaction forces reach the lumbopelvic tissues differently, and the resultant forces are attenuated differently than in the symmetrical skeleton. For example, with a short right leg the pelvis is tilted down to the right side. This places the right SI joint in a more horizontal position while the left side becomes more vertical. Consequently, more compressive force is applied to the right SI joint and more shear stress is produced on the left.² If any of these forces exceed the tolerance of the tissues, there is a potential for tissue injury. Frontal plane asymmetry potentially alters the mechanics at the SI joint, lumbosacral joint, and the hip joint. For this reason, it is extremely difficult to attempt to isolate one tissue that may be at fault. It is more logical to attempt to improve faulty mechanics that may have contributed to the painful condition.²
The role of the SI joint in low back pain remains controversial with the exception of the spondyloarthropathies. For example, any patient complaining of diffuse low back pain of insidious onset in the SI region who presents with stiffness and difficulty in spinal movements should be evaluated medically to rule out ankylosing spondylitis. The disease process begins in the low back, specifically the SI and lower lumbar zygapophyseal joints. The involved joints are marked by enthesopathy, an inflammation at the site of ligamentous attachment to the bone. Periodic episodes of joint pain then progress to fibrous ankylosis, and ultimately to bony ankylosis. Because the disease process is inflammatory and the SI joint has the same characteristics of other synovial joints, it is considered to be a potential source of pain.
CHAPTER VI

DIAGNOSIS

The diagnosis of somatic dysfunction of the SI joints is based upon a dysfunction in joint movement, tissue texture changes which usually accompany joint dysfunction, and asymmetry of pelvic landmarks which provides supportive data for the diagnosis. The primary diagnostic criteria relied on have been pain in the buttock or SI joint, pain elicitation in the SI joint by provocation, and absence of other factors such as disc lesion, sciatica, radiating pain, or neurological deficit. The examiner must be able to differentiate a variety of causes of SI joint pain such as sprain, subluxation, or ankylosing spondylitis. The examiner must also perform additional evaluative procedures because SI joint dysfunction may occur and exist with other problems. These include movements of the spine and hip, tests of muscle strength, and palpation of the abdomen. Diagnosis can often be clarified with a careful history and physical examination.

The following are examples of questions the examiner should ask the patient concerning his/her history and onset of a dysfunction:
1) What was the mechanism of injury? A sudden sharp jolt to the leg with the knee extended, a fall directly onto the buttocks, or sudden trunk flexion with rotation are common causes of SI strain.46

2) Where is the pain and does it radiate? Ask the patient to describe characteristics of the pain including the location, type, and intensity. Forward bending is usually limited and painful when the patient is standing, but improves when the patient is seated.4 With a lesion of the SI joint, pain can be referred to the posterior thigh, iliac fossa, or the buttock on the affected side. Muscle spasm is not a prominent feature and the neurological examination is usually normal.4

3) Is there any particular position or activity that aggravates the condition? Getting out of a bed, climbing or descending stairs, or standing from a seated position all stress the SI joint.46

4) If the patient is female, has there been a recent pregnancy? A sprain of the SI ligaments can be the result of increased laxity caused by hormonal changes.46

5) Does the patient have a history of rheumatoid arthritis, Reiter's disease, or ankylosing spondylitis? Morning stiffness may be indicative of rheumatologic or degenerative processes.46

The examination process seeks to determine if there is a problem using one or more screening tests, locate the problem by palpatory scanning tests, and define it by testing the pelvic joints for mobility.8 Tests can be classified I
through V according to the categories suggested by Dinnar. Classes I and II are screening tests; classes II and III are used as scanning procedures; while classes III, IV, and V are used to define the problem.

Class I tests are general observational and palpation tests used to screen the patient for a SI dysfunction. Observations are made of stance, posture, spinal curves, and gait. Forward or backward sacral torsion may increase or decrease lumbar lordosis. A painful SI joint may cause reflex inhibition of the gluteus medius, leading to a Trendelenburg gait or lurch. Careful palpation associated with testing for SI joint dysfunction can usually help confirm the diagnosis. Palpation of landmarks such as iliac crests, trochanters, anterior superior iliac spines (ASIs), posterior superior iliac spines (PSIs), and pubic tubercles is performed for symmetry. Regional palpation for muscle tone, contour, and contraction or hypertonus is also included in this class. The examiner should observe any unilateral or bilateral spasm of the erector spinae musculature. Buttock contour over a painful SI joint will may be flatter due to the loss of tone in the gluteus maximus muscle.

Class II tests are regional motion tests used to screen the patient to see if there are any asymmetries in gross motion which might be associated with pelvic dysfunction. In young people, motion palpation tests are practical and usually informative. With the degenerative changes that occur with increasing age, the motion is more difficult to detect and joint play is more conclusive. As the joints may vary in degree of motion from person to person and from side
to side, comparison of one side to the other is necessary. This group of tests are conducted in standing, sitting, and supine.

The standing tests include the following:

1) **Standing flexion test:** The patient is standing while the examiner notes the level of the PSISs. As the patient flexes forward, the examiner notes the cranial movements of the PSISs. The side that moves first or farthest cranially is the blocked side. This test may be thought of as iliosacral motion recruited from the top down.

2) **Gillet's test:** Again, the level of the PSISs are noted while the patient is standing. The patient is then asked to stand on one leg while pulling the opposite knee up toward the chest. The test is repeated with the other leg. If the PSIS on the flexed side moves downward or inferiorly, this is considered normal. If the PSIS on the flexed side moves minimally or not at all, the SI joint on that side is hypomobile or "blocked" indicating a positive test. Recruitment here is from the bottom up.

3) **Flamingo test:** The patient is standing and then asked to stand on one leg. Pain in one of the SI joints or the symphysis pubis indicates a positive test for lesions in whichever structure is painful. The stress may be increased by having the patient hop on one leg.

The tests performed in sitting include the following:
1) **Sitting flexion test**: In a sitting position, the examiner notes the level of the PSISs. The patient is asked to cross the arms across the chest and pass the elbows between the knees as if to touch the floor. The PSIS on the involved side will move first or farthest cranially. If blockage is detected in this test, and it is greater than the restriction found in the standing flexion test, this is indicative of a sacral dysfunction. If the two PSISs move symmetrically, then an innominate dysfunction is present.\(^4^6\)

2) **Piedallu’s sign**: The patient is asked to sit on a hard, level surface. This position keeps the hamstrings from affecting the pelvic flexion symmetry. The examiner palpates the PSISs and compares their heights. Usually the PSIS on the affected side will be lower. The patient is asked to flex forward while remaining seated. If the lower PSIS becomes the higher one, the test is considered positive. This indicates an abnormality in the torsion movement at the SI joint on that side.\(^4^6\)

Tests with the patient supine include the following:

1) **Straight leg raising (SLR) test**: This is a passive test and the legs are tested individually, then together. With the patient supine and the knee extended, the examiner flexes the hip until the patient complains of pain or tightness. When the leg is raised, the pull of the hamstrings on the innominate bone causes a posterior torsion strain on the same
side. A unilateral SLR test is full at 70 degrees, so pain experienced after that is probably joint pain from the lumbar area or the SI joint. The examiner should suspect a posterior or vertical complication on that side. If pain is felt on the contralateral side, the examiner should suspect an anterior dysfunction on the opposite side because rotating one innominate posteriorly may increase anterior dysfunction on the opposite side. If a bilateral SLR test is performed and the patient experiences pain before 70 degrees, a SI joint lesion should be expected.

2) **Supine to sit test:** The patient lies supine with the legs straight. With the examiner's help, the patient is asked to raise up into the long-sitting position. If the lower extremity on the affected side appears longer when the patient is supine but shorter when sitting, the test is positive. This is indicative of an anterior innominate rotation on the affected side. If the extremity seems shorter while supine and longer when sitting, a posterior innominate rotation is suspected.

Class III tests assess positional landmarks and are used to identify asymmetry of position which suggests an alteration in pelvic or general body mechanics. Landmarks examined are the ASISs, PSISs, iliac crests, and the pubic tubercles. One side is always compared to the other. If the ASIS is lower and the PSIS is higher on the same side, the examiner should suspect a counternutation. If a counternutation is present, which indicates an anterior
torsion of the joint on that side, the lower extremity on that side may appear medially rotated. If the ASIS is higher and the PSIS is lower on the same side, a nutation is suspected. This may also indicate a torsion of the sacrum on that side. This torsion may result in a spinal scoliosis and/or an altered functional leg length. If the ASIS and the PSIS on the same side are higher than the ASIS and PSIS on the other side, this indicates an upslip of the ilium on the sacrum on the high side.

The level of the iliac crests should be checked first with the patient standing, then with the patient sitting on a firm surface. This will help determine whether a high iliac crest is caused by a difference in leg length resulting in a pelvic obliquity or a pelvic obliquity is causing an apparent difference in leg length. If one crest is still higher with the patient sitting, then it is probable that a pelvic obliquity caused the leg length discrepancy.28

The examiner can test to see if both pubic bones are level at the symphysis pubis by placing one finger or thumb on the superior aspect of each bone. If the ASIS on one side is higher, the pubic bone on that side should also be higher, indicating a backward torsion problem on that side.46

Class IV tests of superficial and deep soft tissues are used to identify areas of tissue texture abnormality resulting from inflammation, nerve irritation, or injury. Asymmetries in soft tissues are associated with relative changes in the position of the sacrum and the ilia. Light touch palpation is used to examine the skin and subcutaneous tissue for temperature, edema, and
contour. Ligaments are examined by utilizing pressure and/or shearing stress. The ligaments commonly tested are the anterior, posterior, and sacrotuberous.\(^8\)

Examples of anterior SI ligament tests include:

1) **Gapping test**: The patient lies supine while the examiner applies crossed-arm pressure to each ASIS in an inferior and lateral direction. This test is considered positive if unilateral gluteal or posterior leg pain is produced.\(^4^6\)

2) **Yeoman's test**: As the patient lies prone, the examiner flexes the patient's knee to 90 degrees and extends the hip. Pain localized to the SI joint on the same side indicates pathology of the anterior ligaments.\(^4^6\)

Examples of posterior SI ligament tests include:

1) **Approximation test**: The patient is sidelying while the examiner's hands are placed over the upper part of the iliac crests. The examiner then presses down toward the floor. An increased feeling of pressure in the SI joints indicates a possible sprain of the ligaments.\(^4^6\)

2) **Squish test**: With the patient in the supine position, the examiner places both hands on the patient's ASISs and iliac crests. Pressure is applied in an inferior and medial direction at a 45 degree angle. A positive test is indicated by pain at either SI joint.\(^4^6\)

To test the integrity of the sacrotuberous ligament, the patient lies supine. The examiner flexes the patient's knee and hip fully and then adducts the hip.
The knee is then moved toward the opposite shoulder. A longitudinal force is then applied through the hip in a slow, steady manner in an oblique and lateral direction. The examiner tests both sides. Pain in the SI joint on the same side indicates a positive test.46

Class V tests, which test for local response to motion demand, are used to identify motion dysfunction at the SI joints.9 An example of this class is the prone gapping test or Hibb’s test.46 The patient’s hips must have full range of motion and be free of any pathology. The patient lies prone while the examiner stabilizes the pelvis with his/her chest. The patient’s knee is flexed to 90 degrees and the hip is medially rotated as far as possible. While pushing the hip into extreme medial rotation, the examiner palpates the SI joint on the same side. The test is repeated on the other side, with the examiner comparing the range and the quality of the movement at each SI joint.

Even though there are a number of tests available for clinicians to use to help identify SI joint dysfunction, intertester reliability is lacking. Reliability, or reproducibility, is necessary for a test measure to yield meaningful results.48 A study examining intertester reliability using thirteen of the most common tests was reported in 1985.48 Eight therapists with a mean of 7.6 years of clinical experience evaluated 17 patients whose chief complaint was unilateral buttock pain. The tests were performed in an order indicated by patient position. Two therapists at two different sports medicine outpatient clinics were assigned to different patients. The first therapist evaluated the patient and the results were
noted. The second therapist, selected from a random pairing sheet, examined the same patient and noted the findings on a separate chart. The data sheets were sealed in an envelope and were not examined until after the study was completed at both clinics. The results showed intertester reliability was generally poor for all tests except the compression and gapping tests, which achieved about 70% and 90% agreement respectively. Interestingly, these were the only two tests that relied solely on subjective patient response and imparted no information on SI joint position or mobility. None of the other tests exhibited more than 50% agreement. In fact, one test, the prone knee flexion test, showed only 23% agreement.

The SI joints present a unique problem to the diagnostician because pain occurring in this area may not always be of mechanical origin. The patient could be experiencing inflammatory sacroiliitis from an infection or one of a variety of seronegative spondyloarthropathies, such as ankylosing spondylitis. Since the SI joints are not always amenable to palpation, this sometimes forces one to rely on imaging modalities to help diagnose disease and dysfunction. These modalities include the plain radiograph, scintigraphy, computed tomographic (CT) scans, and magnetic resonance imaging.

The plain radiograph is always the initial tool used to evaluate the SI joints. The normal obliquity of the joints results in an overlap of the ilium with the sacrum, obscuring most of the joint space. However, the inferior aspect of the posterior surface of the joint is tangential to the radiation beam and can be
evaluated for destructive changes. The Ferguson view and the Chamberlain technique are common plain film procedures for viewing dysfunction of the SI joints.

With the Ferguson procedure, the patient is positioned supine for an anteroposterior view with the beam angled 25-30 degrees caudally. The advantage of this method is that it allows direct comparison of the two SI joints on a single film, increasing the sensitivity of detecting subtle changes of inflammatory arthritis. Because the SI joints and the symphyseal joint (pubis symphysis) must be continuous by means of the pelvic ring, evidence of instability of the SI joint can sometimes be demonstrated more easily by visualization of the symphyseal joint. This is accomplished by using the Chamberlain technique. Anterior and posterior radiographs are made while the patient is standing, first on one foot and then on the other. The normal range of excursion of the symphyseal joint is 2 mm, which can be easily measured when the two films are superimposed on each other.

Scintigraphy is the photography of scintillations emitted by radioactive substances injected into the body. Two isotopes have proved invaluable for confirming disease of the SI joints: technetium MDP and gallium 64. Technetium MDP is an extremely sensitive but nonspecific marker, concentrating in areas of hyperemia and increased bone turnover. Its lack of specificity and normal intense concentration at the SI joints limits its usefulness to one clinical situation: confirming unilateral sacroiliitis in the presence of
normal plain films. Gallium 64 reflects bone turnover to a degree, but its specificity for areas of infection and certain tumors makes it a valuable tool to evaluate the elusive SI joint. Like technetium MDP, gallium 64 is limited to a single clinical situation: focal accumulation of gallium is diagnostic of infection.

The primary use of a CT scan is for a CT-guided aspiration of the SI joint when infection is suspected. Because of the obliquity of the joint, it is far superior to fluoroscopic guidance to direct the needle into the joint capsule to obtain fluid for culture and bacterial stains. When plain films are equivocally abnormal and there is suspicion of the onset of a seronegative spondyloarthritis, a CT scan is performed. A CT scan documents inflammatory changes of the joints by demonstrating the erosive changes better than the plain film.

Magnetic resonance imaging (MRI) is superior to other musculoskeletal imaging modalities for visualizing marrow, cartilage, and ligamentous structures directly. Coronal imaging of the SI joints, parallel to the plane of the sacrum, allows direct comparison of one joint to the other. By obliquing the patient to compensate for the angle of the SI joint, true coronal sections can be obtained, allowing more accurate analysis of the joint margins. Murphey and associates found MRI to be superior to CT for evaluation of cartilage and detection of erosions. MRI was performed on seven asymptomatic volunteers and 17 patients with clinical and radiologic evidence of sacroiliitis. Four SI joints of the volunteers and two of the patients with MRI findings of sacroiliitis were negative.
The authors concluded that MRI is a valuable method for detecting sacroiliitis, particularly when results of other imaging techniques are inconclusive.⁵⁰
CHAPTER VII

CONCLUSION

Compared with other human synovial joints, the SI joint is unique and fascinating. Lesions of this joint can be biomechanical in origin or the result of a degenerative process. Dysfunction is related to inequality of leg length and pelvic obliquity. It is associated with pain during a passive straight leg raise and pain during pregnancy. What range of motion exists appears to be very small indeed, and probably rarely occurs in true cardinal planes. Accurate correlation between motion and joint dysfunction should lead to a better understanding of SI problems and their treatment.

Clinicians should use caution in their interpretation of dysfunction. Continuity of patient care and repeatedly effective treatment regimens are unlikely unless evaluation techniques are reliable. Improved clinical diagnosis should result from more clearly defined relationships between test findings and joint dysfunction.

Despite the lack of objective diagnostic criteria and a poor understanding of the pathogenesis of mechanical back syndromes, many practitioners treat the SI joints in patients with low back pain and obtain good results. Correction and prevention of SI joint dysfunction is quite simple and effective. However,
success with treatment does not necessarily prove the existence of dysfunction. In order to establish a cause and effect relationship and to further understand the role this joint plays in mechanical low back pain, more clinical and basic science research is required.
REFERENCES


