PELVIS AND SACROILIAC JOINT

Prepared by

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Lecture Outline:

Pelvic Bones and Joints

The pelvis consists of three bones (hip bones X 2 & sacrum) and three joints (symphysis pubis & sacroiliac joint X 2).

Each hip bone initially consists of three bones (ilium, ischium & pubis).

The junction between the three bones lies within the acetabular fossa. The pubis forms the upper and anterior fifth of the articular surface of the acetabulum; the ischium, the floor of the acetabular fossa and rather more than the lower and posterior two-fifths of the articular surface; the ilium forms the remainder of the articular surface.

The primary ossification centre of the ilium appears immediately above the greater sciatic notch at about Week 8; the one for the ischium appears in its body in the 4^{th} month, and that for the pubis in the superior ramus between the 4^{th} and 5^{th} months. During the 7^{th} or 8^{th} year the ischium and pubis fuse. Secondary centres appear during puberty and fusion occurs between the 15^{th} and 25^{th} year.

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Sexual Dimorphism in Pelvis

Sexual dimorphism is obvious in the pelvis.

The primary function of the pelvis in both sexes is postural and locomotor (transmitting the weight of the upper body to the lower limbs), however there is an additional function of childbirth in the female.

In the male the subpubic angle is approximately equal to the largest angle formed between the second and third digits of the hand, while the female subpubic angle is similar to the largest angle formed between the thumb and index finger.

The greater sciatic notch also has a larger angle in the female; it is "J"-shaped in the male and "L"-shaped in the female. The pubic tubercles are further apart in the female, as are the ischial spines.

The width across the iliac crests (biiliocristal diameter) is often greater in the male because of the greater absolute size of adult males, in general. The major size differences are between the true pelvis diameters rather than the dimensions of the false pelvis.

At the hip joint, the acetabulum is absolutely larger in the male, and its diameter is approximately equal to the distance of its anterior rim from the symphysis. In the female, this distance is much greater, not only because the acetabulum is smaller, but also because the whole of the anterolateral wall of the pelvic cavity is comparatively wider in the female. There is a tendency for the female acetabula to be further apart and to also face more anteriorly which affect the "natural" plane of hip flexion/extension ("spin" motion).

It is generally accepted that in the standing position, a vertical plane passes through the ASISs and the front of the symphysis pubis. This relates to a horizontal planes through the ASISs and

PSISs.

However, Smidt and his associates (1984) found that in about 2/3 of male subjects, a plane through the ASISs and PSISs sloped forward and downward by between 4 and 15 degrees.

The pubic symphysis consists of an interpubic disc of both hyaline cartilage (peripherally) and fibrocartilage (centrally), strengthened by the superior pubic ligament and the arcuate pubic ligament (inferiorly).

The sacrum is a double wedge with the

- superior width > inferior, and
- anterior > posterior (Don Tigny 1985)

The lumbosacral load bearing area is relatively larger in male than female, while the total width of male and female sacra are similar (cf pelvic width).

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Classification and Structure of SIJ

The sacroiliac joint (SIJ) is a true synovial joint (Lavignolle *et al* 1983) which may be plane??

Structure (articular surfaces)

Sacral articular surface

- convex? (Don Tigny 1985)
- concave? (Porterfield & De Rosa 1990)
- lined with hyaline cartilage(Porterfield & De Rosa 1990)

Iliac articular surface

- concave? (Don Tigny 1985)
- convex? (Porterfield & De Rosa 1990)
- lined with thin fibrocartilage (Porterfield & De Rosa 1990)

The surfaces are NOT plane because there are irregular elevations/depressions in adults.

Both articular surfaces are L-shaped being convex anteriorly and concave posteriorly, with the inferior surface having a larger area (Porterfield & De Rosa 1990).

The two surfaces (sacral and iliac) are congruent and almost of equal size (Bakland & Hansen 1984). The maximum anterosuperior dimensions are 29 mm (both sacral and iliac; Bakland & Hansen 1984) to 39 mm (Miller *et al* 1987) and the maximum superoinferior dimensions are 63-64 mm (both sacral and iliac) (Bakland & Hansen 1984, Miller *et al* 1987). The surface area is about 14 cm^2 on each side, compared with the L3-4 intervertebral disc which is about 20 cm^2 (Miller *et al* 1987). Eighty-seven percent (87%) of the total area is formed by S1, S2, S3 (Porterfield & De Rosa 1990).

Just posterior to the main joint at about its mid-level is an "axial sacroiliac joint" (Bakland & Hansen 1984).

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Associated Ligaments

Anterior sacroiliac ligament

This is a capsular ligament, being a thickening of the anterior and inferior capsule. It is particularly well-developed at about the level of the posterior superior iliac spines (PSIS) where it connects S3 to the lateral margin of the pre-auricular sulcus; it is thin elsewhere.

Interosseous sacroiliac ligament

This is a massive ligament, being the main ligament that holds the bones together. It fills the irregular space immediately above and behind the joint (SIJ) (Porterfield & De Rosa 1990). It consists of two parts; superficial and deep. The deep part consists of two bands; a superior band and an inferior band. The superior band unites the superior articular process plus the lateral crest on the sacrum to the ilium (short posterior sacroiliac ligament).

Posterior sacroiliac ligament

This ligament overlies the interosseous sacroiliac ligament. Between these two ligaments lie the posterior rami of the sacral spinal nerves and various blood vessels. The lower fibres joining S3 and S4 to the PSIS may be called the long posterior sacroiliac ligament. The long posterior sacroiliac ligament is continuous;

- laterally with the sacrotuberous fibres, and
- medially with the posterior layer of the thoracolumbar fascia (TLF)

The total area of attachment of the posterior ligaments on each side is 22 cm^2 (Miller *et al* 1987) which is very large compared with the size of the joint.

Sacrotuberous ligament

It has wide attachments from the pelvis (PSIS + lower transverse tubercle of the sacrum + lateral margin of the lower sacrum + upper coccyx) and the fibres converge towards the medial margin of the ischial tuberosity. Attached to this ligament are the inferior fibres of *gluteus maximus* and the long head of *biceps femoris*. The ligament is pierced by perforating cutaneous nerves and minute filaments of the coccygeal plexus.

Sacrospinous ligament

This ligament is thin and triangular. It attaches to the lateral margins of the sacrum and coccyx (anterior to the fibres of the sacrotuberous ligament) and then to the ischial spine at the other end.

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Functions of SIJ

The SIJs transmit weight from the vertebral column to the pelvis and they also transmit the ground reaction force from the lower limbs to the trunk during gait.

Normally the line of weight lies anterior to the centre of rotation of the SIJs during standing (Porterfield & De Rosa 1990) and posterior to the hip joints (or it passes through the hip joints).

The SIJs function to absorb shearing forces at heel strike during walking (DonTigny 1985). The upper body has forward momentum and there is a retarding force on the lower body due to the ground reaction force (GRF). The resulting force couple tends to produce a trunk flexion moments and an anterior shear on structures relative to the adjoining inferior structures (DonTigny 1985).

Movements

Motion in the SIJ is the subject of lively debate (Porterfield & De Rosa 1990).

"Rotation can only occur when there is separation of the articular surfaces due to moderate relaxation of the ligaments, thus accounting for the accompanying translation" (Lavignollo *et al* 1983).

In an in vivo radiographic study in which the subjects were not weight bearing through their SIJs the instantaneous centre of rotation (ICR) was found to be near the pubic symphysis, indicating a relatively large amount of translation associated with the angular motion. There was 12^{o} of flexion (nutation) with an associated anterior iliac translation of 6 mm with respect to the sacrum (Lavignollo *et al* 1983).

A recent review concluded that rotation (flexion) occurred about a horizontal axis through the SIJs at the intersection of the superior and inferior portions of the articular surfaces (Porterfield & De Rosa 1990).

An X-ray stereophotogrammetric study (Sturesson *et al* 1989) found less movement in the SIJs than previous authors. They studied five postures;

- supine
- standing
- sitting with extended knees (long sitting)
- prone with extended left hip
- prone with extended right hip

and found a total rotation about the X-axis (mediolateral) of 2.5^{o} and a total translation of 0.7 mm.

Mechanical Properties

The following comparisons between the SIJ and LMS (lumbar motion segment) have been made (Miller *et al* 1987).

SIJ = 5% LMS (stiffness for axial load)

SIJ = 624% LMS (stiffness for medially directed load - shear)

SIJ = 64% LMS (stiffness for axial torsion)

SIJ = 700% LMS (stiffness for lateral bending)

Stabilisation

he posterior sacroiliac ligaments are extremely thick and strong and contribute directly to SIJ stability (Porterfield & De Rosa 1990). Vertical loading (eg. weight bearing) produces a downward motion plus rotation (Vukicevic *et al* 1982). During normal standing, the upper body weight on the anterosuperior aspect of the sacrum produces an anterior sacral tilt (flexion; Porterfield & De Rosa 1990) which causes it to sink forward and downward. This potential motion puts the posterior sacroiliac ligaments (posterior sacroiliac plus sacrotuberous plus sacrospinous) on stretch, which is an automatic locking device or "screw home mechanism" (Don Tigny 1985, Porterfield & De Rosa 1990). During normal standing, the centre of gravity passes just posterior to the centre of the acetabulum (hip joint) and therefore the weight passes through the posterior pelvis which tends to posteriorly tilt the pelvis (DonTigny 1985, Porterfield & De Rosa 1990). The SIJs are NON weightbearing but the sacroiliac ligaments are! (DonTigny 1985).

During standing, the weight may shift from side to side. If the lateral pelvic tilt is to the right, the right SIJ is more horizontal and the left is more vertical (Porterfield & De Rosa 1990). These changes in orientation cause increased compression on the right SIJ and increased shear on the left SIJ (Porterfield & De Rosa 1990).

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Growth, Development and Ageing

In the infant, the articular surfaces are "flat" instead of having irregular elevations/depressions as in the adult (Grays 1980).

The hormonal changes associated with pregnancy increase the mobility of the SIJs and increase the vulnerability of the SIJs to sprain for up to four (4) months after childbirth (Porterfield & De Rosa 1990).

Childbirth

The concept of nutation and counternutation (Kapandji 1974) during childbirth is generally well-accepted (Porterfield & De Rosa 1990). Initially, hip extension places tension on the hip flexor muscles (such as rectus femoris) causing an anterior iliac tilt with respect to the sacrum (counternutation). The anterior pelvic tilt effectively increases the distance between the pubic symphysis and the anterosuperior aspect of the sacrum, widening the upper part of the "birth canal". During the next stage, the hips are flexed causing tension in the hamstring muscle group. This tensile force on the ischial tuberosities produces a posterior tilt of the hip bones with respect to the sacrum (nutation). Nutation causes an increase in the distance between the pubic symphysis and the coccyx, effectively widening the lower part of the birth canal.

Ageing

During ageing, there is an increase in the fibrous adhesions within the SIJ and a consequent decrease in size of the synovial cavity (Gray's Anatomy 1980). There may even be ossification of the SIJs (Gray's Anatomy 1980). From the 3rd-4th decade onwards, there is decreased mobility associated with physiological joint fusion (Porterfield & De Rosa 1990). In almost 2000 skeletons studied, from age 40 onwards (Stewart 1984), there was evidence of increasing para-articular osteophytosis with age, leading to ankylosis.

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