INTRODUCTION

The sacrum articulates with L5 vertebral body above, the coccyx below and ilium laterally. The lumbosacral junction is located anterior to the sacroiliac joint and because of the forward tilt of the sacrum, its weight is transmitted to the superior surface of the sacrum as a rotatory force tends to tilt the sacral promontory forwards and the apex backwards. There are several osteoligamentous constraints keeping this rotatory force in check also guarding against forward migration of L5 over S1 [(1)].

The axis of rotation at the lumbosacral junction lies in the intersection of middle osteoligamentous column and L5-S1disc. So for constructs that cross the lumbosacral junction only those devices that pass ventral to this point provide significant biomechanical advantage regarding the rigidity of fixation [(33)].

Lumbosacral pelvic fixation techniques are including Iliac Screws (Iliac Bolts), Sacral (S1) Tricortical Pedicle Screws, Iliosacral Screws, S2 Alar Iliac Screws for Pelvic Fixation, Jackson Intrasacral Rods, Galveston Technique, Sacral Sublaminar Wires and Hooks. In addition, circumferential fusion with anteriorly placed bone, bone substitutes, and/or various implants have been proposed for anterior column support and fusion [(35)].

There are many clinical indications for sacropelvic fixation, including long fusions extending to the sacrum, flat-back deformity, pelvic obliquity, high-grade spondylolisthesis, sacrectomy, sacral fractures with spinopelvic dissociation[25]

Iliac Screws is a modularity of newer spinal instrumentation allows for the insertion of screws in the ilium, independent of other points of fixation. Offset connectors are then used to connect the screws to the longitudinal rods. The pullout strength of iliac screws has been shown to be 3 times higher than that of Galveston rods. The placement of iliac screws or rods is a major surgical procedure, the technique requires extensive surgical exposure, which is associated with a high risk of blood loss and infection.however, in a through two-year study of patients treated with iliac fixation, kuklo et al.[35] reported an infection rate of 4%. Other complication associated with iliac screw fixation include development of hollows around the iliac rods and screws, injury to structures in the sciatic notch, acetabbular violation, and hardware prominence[35],[27].

ANATOMY OF THE LUMBOSACRAL AND SPINOPELVIC REGIONS

The lumbosacral pelvic junction is a unique region of the axial skeleton, situated in the posteroinferior part of the trunk, in which mobile lumbar vertebrae articulate with rigid sacrum, through which, forces and loads of the trunk and upper body meet those of the pelvis and lower body. (1)

The lumbosacral pelvic junction consists of the last three lumbar vertebrae, the upper three segments of the sacrum, and that part of the ilium in proximity to the sacroiliac joints (fig.1). It has an osteoarticular axis, powered by musculofascial elements, and is traversed by neuromuscular structures that supply and control them. (2)

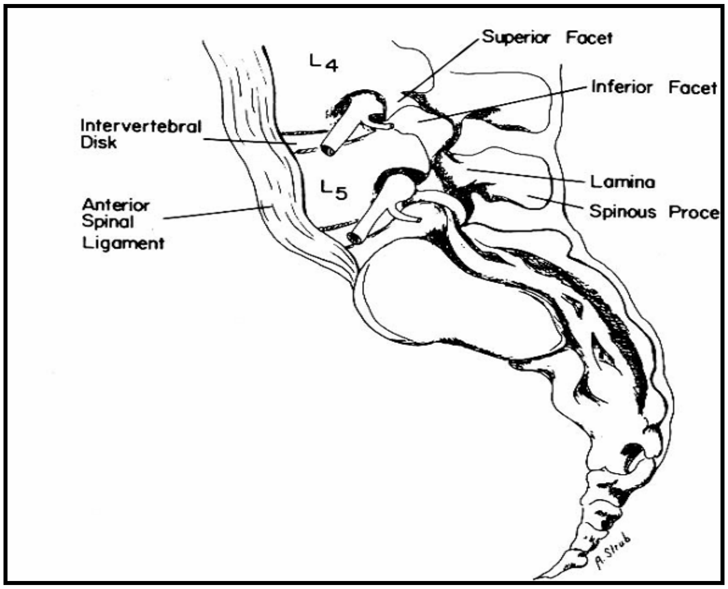

Fig. (1): Schematic diagram shows sagittal section of L4, L5, and sacrum(2)

Conceptually, a lumbar vertebra may be divided into three functional components (Fig 2). These are the vertebral body, the pedicles and the posterior elements. Each of these components subserves a unique function but each contributes to the integrated function of the whole vertebra (3).

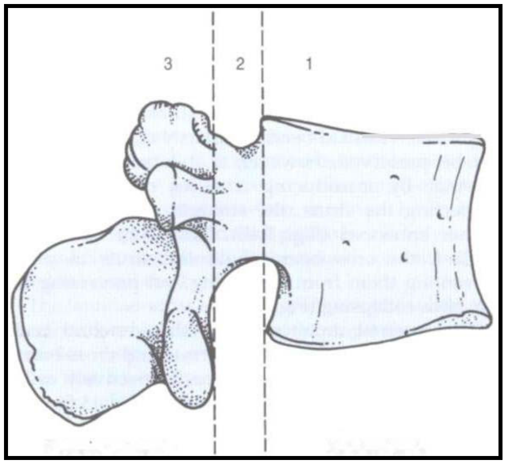

Fig. (2): The division of a lumbar vertebra into its three functional components.

Vertebral body:

The vertebral body subserves the weight-bearing function of the vertebra and is perfectly designed for this purpose. Its flat superior and inferior surfaces are dedicated to supporting longitudinally applied loads.

The load-bearing design of the vertebral body is also reflected in its internal structure. The vertebral body is not a solid block of bone but a shell of cortical bone surrounding a cancellous cavity. This shell is not strong enough to sustain longitudinal compression and would collapse like a cardboard box. It needs to be reinforced. This can be achieved by introducing some vertical struts between the superior and inferior surfaces (Fig.3). The struts and cross-beams are formed by thin rods of bone, respectively called vertical and transverse trabeculae. [3]

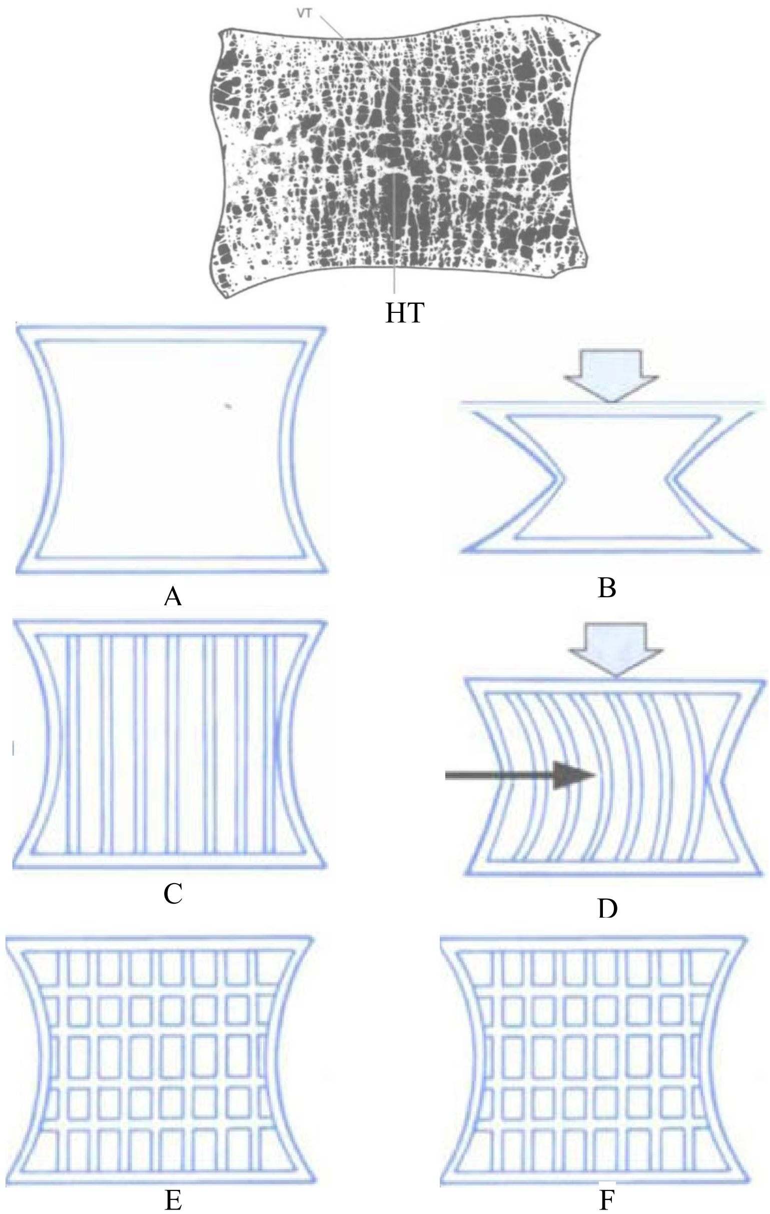

Fig. (3): Reconstruction of the internal architecture of the vertebral body. (A With just a shell of cortical bone. a vertebral body is like a box and collapses when a load is applied (B). (C) Internal vertical struts brace the box (D). (E) Transverse connections prevent the vertical struts from bowing and increase the load-bearing capacity of the box. loads are resisted by tension in the transverse connections (F).[3]

Posterior elements:

The posterior elements of a vertebra are the laminae, the articular processes and the spinous processes (Fig. 2). The transverse processes are not customarily regarded as part of the posterior elements but for present purposes they can be considered together with them. The inferior articular processes form obvious hooks that project downwards. In the intact lumbar vertebral column, these processes will lock into the superior articular processes of the vertebra below, forming synovial joints whose principal function is to provide a locking mechanism that resists forward sliding and twisting of the vertebral bodies. The spinous, transverse, accessory and mamillary processes provide areas for muscle attachments.

Moreover, the longer processes (the transverse and spinous processes) form substantial levers, which enhance the action of the muscles that attach to them [(3)].

Region of the posterior elements of the spine is prone to failure when subjected to repetitive stress:

The pars interarticularis is an area of force concentration and is subject to failure with repetitive stress. A defect in the bony arch in this location is termed spondylolysis. The pars interarticularis is the concave lateral part of the lamina that connects the superior and inferior articular facets. The medial border of the pedicle is in line with the lateral border of the pars between L1 and L4. At L5 the lateral border of the pars marks the middle of the pedicle [4].

Pedicles:

The pedicles are the only connection between the posterior elements and the vertebral bodies. As described above, the bodies are designed for weight bearing but cannot resist sliding or twisting movements, while the posterior elements are adapted to receive various forces, the articular processes locking against rotations and forward slides, and the other processes receiving the action of muscles. All forces sustained by any of the posterior elements are ultimately channelled towards the pedicles, which then transmit the benefit of these forces to the vertebral bodies. The trabecular structure of the vertebral body fig. 4a) extends into the posterior elements. Bundles of trabeculae sweep out of the vertebral body, through the pedicles, and into the articular processes, aminae and transverse processes. They reinforce these processes like internal buttresses, and are orientated to resist the forces and deformations that the processes habitually sustain.8 From the superior and inferior surfaces of the vertebral body, longitudinal trabeculae sweep into the inferior and articular processes (Fig. 4B). From opposite sides of the vertebral body, orizontal trabeculae sweep into the laminae and transverse processes (Fig. 4C). Within each process the extrinsic trabeculae from the vertebral body intersect with intrinsic trabeculae from the opposite surface of the process. The trabeculae of the spinous process are difficult to discern in detail, but seem to be anchored in the lamina and along the borders of the process. [3]

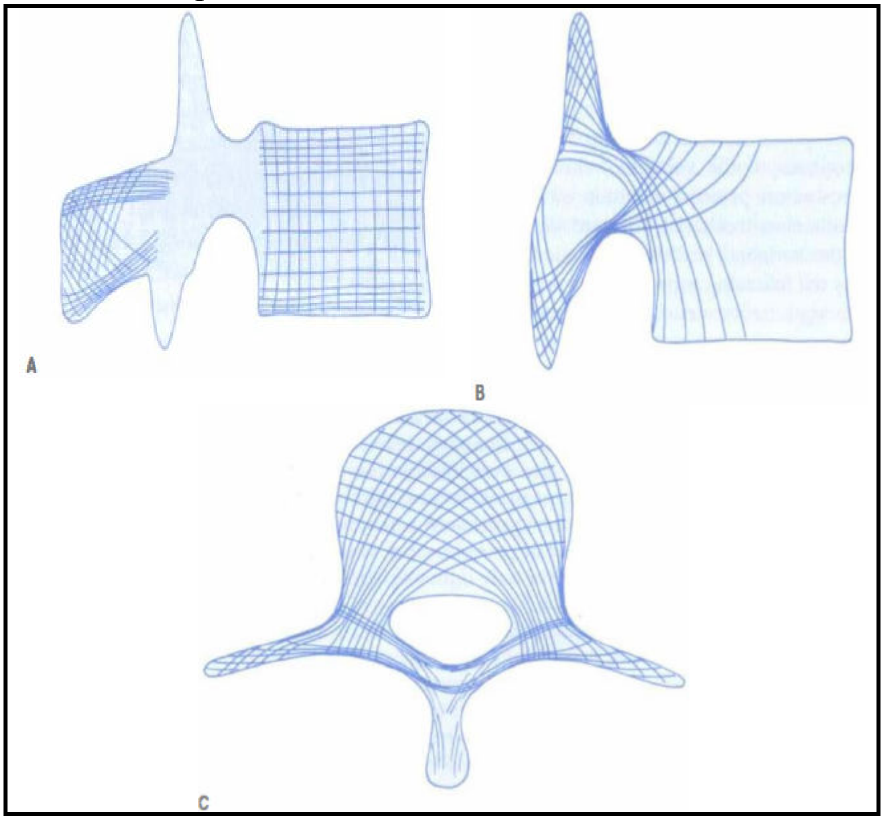

Fig. (4): Internl architecture of a lumbar vertebra. (A) A midsagittal section showing the vertical and horizontal trabeculae of the vtrtebral body, and the trabttulae of the spinous prOtS (B) A lateral saina section showing the trabroJlae pasing through hepedicle into the articular procsses. (C) A transvtrs section showing the trabeulae swetping out of the vertebral body into the laminae and transvtrse processes [3].

The sacrum consist of five fused vertebrae(fig. 5).It has a broad, thick upper end but tapers to a blunt point inferiorly .in the midline anteriorly, the sacrum exhibits rectangular regions that resemble vertebral bodies embedded within the body of sacrum.the top and bottom surfaces of each are marked by transverse ridges between which lie linear regions that resemble narrow intervertebral discs that have ossified. (3)

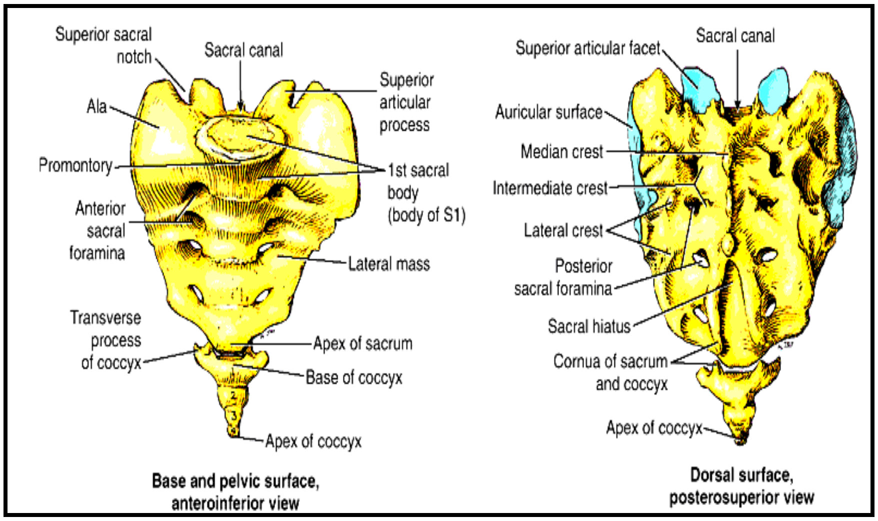

Fig. (5): Diagrams show features of pelvic and dorsal surfaces of the sacrum. (2)

The bulk of the sacrum lies in the bodies and transverse elements of its upper two segment.These segments are designed to allow the sacrum to be locked into the pelvic girdle and to transfere axial forces laterally into the lower limb and vice versa (3)

The Osteoarticular axis:

Posteriorly, the lumbopelvic junction may be separated into two parts: the upper lumbar segment, which is in lordosis, mobile, and situated deep in the body, and the lower sacral segment, which is convex in shape, rigid, and more superficial.[2]

Anatomy of the facet joints of the lumbar spine:

The inferior articular process of the cephalad vertebra is located posterior and medial to the superior articular process of the caudad vertebrae. The upper and mid-lumbar facet joints are oriented in the sagittal plane. This orientation allows signifiant flxion-extension motion in this region but restricts rotation and lateral bending. The facets joints at L5–S1 oriented in the coronal plane, thereby permitting rotation and resisting anterior-posterior translation (fig.6). [3]

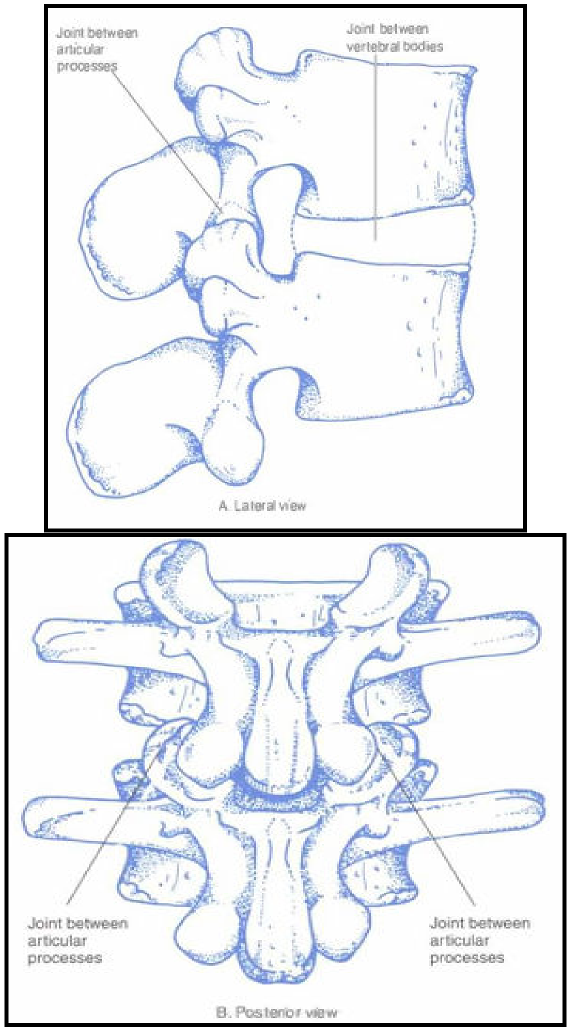

Fig. (6): Diagram shows the joints between lumbar vertebrae [3]

The anatomic structures provide articulations between the lumbar vertebral bodies, between the vertebral arches and between L5 and the sacrum are: anterior longitudinal ligament, posterior longitudinal ligament, and intervertebral disc. [4] The anatomic elements that provide articulations between the adjacent lumbar vertebral arches are: articular capsules, ligamentum flvum, supraspinous ligaments, interspinous ligaments, and intertransverse ligaments. [4]

Specialized ligaments connect L5 and the sacrum:

1- Iliolumbar ligament, which arises from the anteroinferior part of the transverse process of the fith lumbar vertebra and passes inferiorly and laterally to blend with the anterior sacroiliac ligament at the base of the sacrum as well as the inner surface of the ilium.

2- Lumbosacral ligament, which spans from the transverse processes of L5 to the anterosuperior region of the sacral ala and body of S1. [4]

The normal lumbar spine is lordotic (sagittal curve with its convexity located anteriorly). Normal lumbar lordosis (L1–S1) ranges from 30° to 80° with a mean lordosis of 50°. Normal lumbar lordosis generally begins at L1–L2 and gradually increases at each distal level toward the sacrum. The apex of lumbar lordosis is normally located at the L3–L4 disc space. Normally two-thirds of lumbar lordosis is located between L4 and S1 and one-third between L1 and L3 (Fig. 7). Eighty percent of lumbar lordosis occurs through wedging of the intervertebral discs, and 20% is due to the lordotic shape of the vertebral bodies. The wedge shape of the lowest three discs is responsible for one-half of total lumbar lordosis. [4]

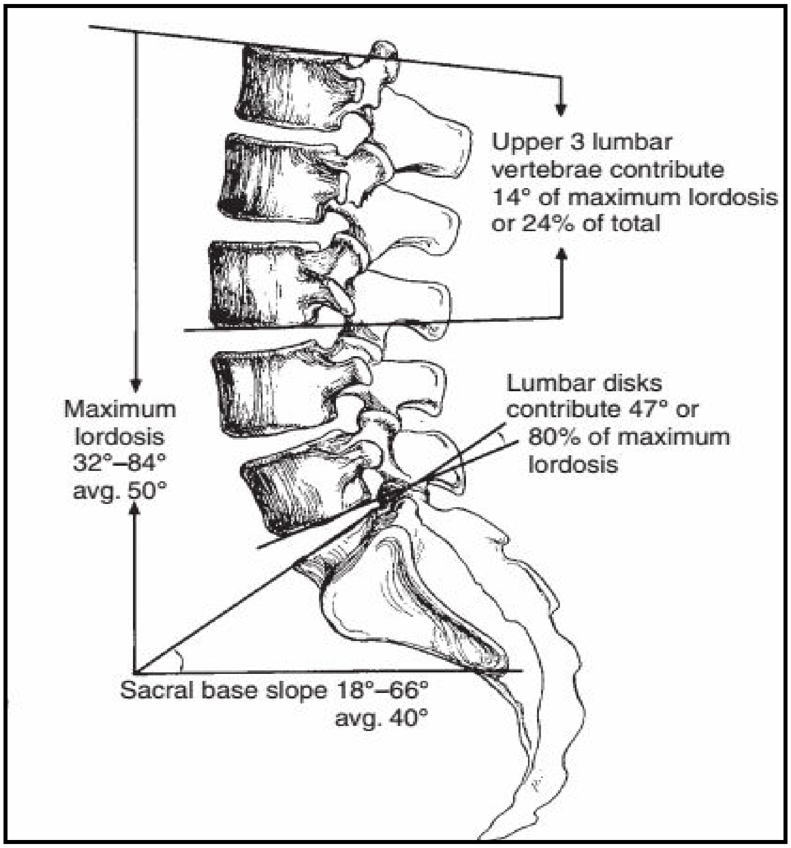

Fig. (7): Diagram shows sagittal alignment of the lumbar spine. Average maximum lordosis as measured from superior L1 to superior S1. [4]

Sacroiliac joint:

The sacrum is connected to each hemipelvis by the sacroiliac joint, which is the largest joint in the axial skeleton. The sacroiliac joint contains a synovial membrane but has minimal motion because of the matching interdigitating contours of the sacral and iliac bones and the strong interosseous, dorsal, ventral, and accessory ligaments. It functions to transfer axial load to each hemipelvis. [5]

The articular surfaces of the ilium and sacrum are L-shaped. In general, the shorter cranial segment is more vertical; the caudal segment is longer and horizontally aligned (Fig. 8). Kapandji, likened the iliac articular surface to a rail segment, that is, the long axis of the iliac surface was described as a long crest lying between two furrows. He described the sacrum as a long axis furrow surrounded by two long crests [5]

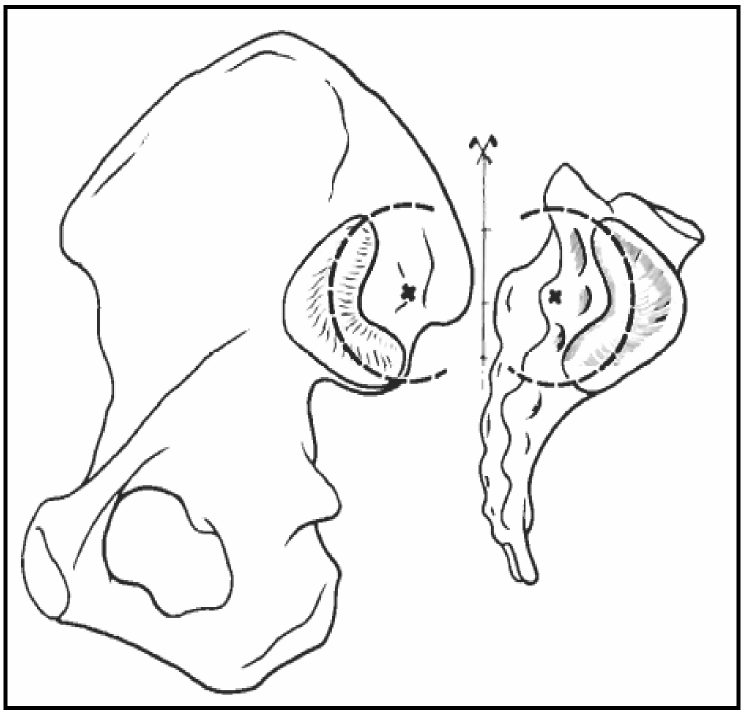

Fig. (8): Diagram shows articular surfaces of sacroiliac joint [6]

The ligaments supporting the pelvis are strong, welldeveloped, and contribute significantly to overall stability. The ventral sacroiliac ligament, made up of an anterosuperior