

The sacrum is typically formed from five fused sacral vertebrae and is triangular in shape; in children the individual vertebrae are separated by cartilage. The superior surface (or base) articulates with the fifth lumbar vertebra at the lumbosacral angle and the inferior apex articulates with the coccyx. It has dorsal, pelvic (ventral) and lateral surfaces. The sacrum is curved, so that in the erect individual the upper part of the pelvic surface is almost horizontal and the lower part almost vertical.

The base of the sacrum is formed by the superior surface of the first sacral vertebra. The large vertebral body is wider transversely than antero-posteriorly and has an anteriorly projecting edge referred to as the 'sacral promontory'. The superior articular processes have postero-medially directed concave superior articular facets for articulation with the inferior articular processes of L5. On the posterior part of each superior articular process is a rough area homologous to a lumbar mamillary process.

The sacral alae (lateral masses) are enlarged lateral parts of the sacral vertebrae. They consist of the embryonic costal elements fused with the vertebral body, pedicles and transverse processes. In males, the width of the body of S1 is greater than that of the alae, whereas in females the widths are similar.

The apex of the sacrum is formed by the inferior surface of the fifth sacral vertebra and has an oval facet for articulation with the coccyx via the sacrococcygeal intervertebral disc.

The pelvic surface is concave transversely and vertically. Four transverse ridges (remnant intervertebral discs), separating the original sacral vertebral bodies, mark its median part. Lateral to each ridge are antero-laterally directed sacral foramina, which communicate with the sacral vertebral canal. The smooth pelvic surface of the lateral mass gives attachment to the piriformis muscle. The upper part of the pelvic surface is in contact with peritoneum, the lower part with the rectum.

The pelvic surface is more downwards facing in females, increasing the size of the pelvic cavity and making the lumbosacral angle more prominent.

The dorsal surface is convex and irregular with four pairs of dorsal sacral foramina. In the midline, over the roof of the sacral canal is the raised, interrupted, median sacral crest with four (sometimes three) fused spinous tubercles (processes). Lateral to the median sacral crest the sacral canal is closed over by the ossified ligamenta flava and the fused laminae. The arched inferior margin of the fused laminae is called the 'sacral hiatus'. The laminae of S5 (and occasionally S4) do not meet in the midline, exposing the dorsal surface of the vertebral body of S5. Vertically below each articular process of S1, medial to the dorsal foramina, are the intermediate (articular) sacral crests formed by the fused articular processes. The inferior articular processes of S5 project inferiorly either side of the sacral hiatus as the sacral cornua (continuous with the intermediate crests) and articulate with the coccyx. Lateral to the dorsal sacral foramina are the lateral sacral crests representing the fused transverse processes. The dorsal surface of the sacrum gives attachment to parts of the erector spinae and gluteus maximus muscles and the thoracolumbar fascia.

The triangular lateral surface of the sacrum is broad superiorly and divided into a smooth upper anterior auricular surface for **articulation with the ilium** at the sacro-iliac joint, and a rough lower posterior area with three deep impressions. The auricular surface has the appearance of an inverted L, the shorter limb being restricted to S1 and the lower longer limb extending down to S3. Above and behind the **L-shaped auricular surface** is a roughened area for attachment of the strong interosseous sacro-iliac ligament. The cartilage-covered auricular surface, formed entirely by embryonic costal elements, has cranial and caudal elevations and an intermediate depression.

The triangular sacral canal is formed by the sacral vertebral foramina. Due to the oblique sacral orientation in the erect position, the upper (basal) opening faces antero-superiorly. The fused dorsal aspects of the sacral vertebral bodies form the anterior wall of the sacral canal. The lateral wall is formed by the pedicles and intervertebral foramina. The fused laminae, spinous processes and ossified ligamenta flava form the posterior wall. Between the sacral cornua, the posterior wall is deficient inferiorly; this lower opening is called the '**sacral hiatus**' and is closed by fibrous tissue.

The sacral canal contains the lower dural sac (to the level of S2) with the **cauda equina**, **filum terminale**, cerebrospinal fluid (CSF), the internal vertebral venous plexuses, spinal nerves and fat.

There are paired rows of sacral foramina, which emerge on the dorsal and pelvic surfaces. These divide the bone into a central part, formed by the fused vertebral bodies, and the paired lateral masses, which represent the fused embryonic costal elements and transverse processes. The ventral (pelvic) and dorsal sacral foramina communicate with the corresponding intervertebral foramina at each level and convey ventral and dorsal rami of the sacral spinal nerves, respectively.

### **Variations**

Transitional vertebrae occur at the regions of the spine where the morphologic characteristics of the vertebrae markedly change from one area to the next. Transitional segments result in variations in vertebral number and/or identity and are most common at the lumbosacral junction.

Incorporation of the last lumbar vertebra into the sacrum (sacralization) reduces the number of lumbar vertebrae to four and separation of the first sacral vertebra from the sacrum (**lumbarization**) typically increases the number of lumbar vertebrae to six. The transitional segment may become partially or completely fused to the adjacent segment.

### **Ossification**

Ossification of the sacral vertebrae is similar to that of a typical vertebra, ossifying from three primary centers. These centers appear in the centrum and in each half of the vertebral arch in-utero between the tenth and twentieth weeks. Centers for the embryonic costal elements of the upper four segments appear between the sixth and eighth prenatal months.

The embryonic costal elements fuse with the ipsilateral half of each vertebral arch between the ages of two and five years. The arches fuse with the body by the eighth year and with each other by the tenth year. Secondary centers for the upper and lower surfaces of the vertebral bodies, spinous processes and transverse tubercles and the embryonic costal elements appear during puberty. During puberty the lateral mass segments fuse from below upwards. The sacral vertebral bodies fuse at their adjacent margins after the age of 20 years, but the regions containing the intervertebral discs remain un-ossified up to and beyond middle age. Other secondary ossification centers fuse between the ages of 18 and 25 years.