# Functional Unit

The vertebral column, which in its lumbar area is the site of pain, can best be evaluated by understanding of the functional units that comprise the vertebral column. The functional unit is composed of two segments: the anterior portion, which functions in directional guidance.

## Anterior Portion:

The weight-bearing portion of each functional unit is the anterior portion, which is comprised of two vertebral bodies separated by a hydrodynamic shock absorber, the intervertebral disk.

The intervertebral disk is a fibrocartilaginous body securely connecting two adjacent vertebral bodies. The individual disk comprises three parts:

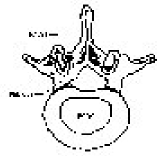

***Figure 19a:*** *Functional vertebral unit. View of the vertebral body, the posterior articulations (facets), the pedicles, the processes (P), and the lamina(L).*

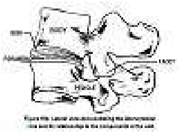

***Figure 19b:*** *Lateral view demonstrating the intervertebral disk and its relationship to the components of the unit.*

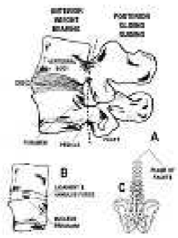

***Figure.20:*** *The functional unit of the spine in cross section: A, Lateral view; B. Shows pressure within disk, which forces vertebrae apart, and the balancing force of the long ligaments; C, Gliding motion of the plane of the facets.*

Aging plus multiple microtrauma causes the cartilage plates to become thinner and the posterior aspect of the annulus to become fragmented. There is some invasion of granulation tissue from the vertebral body along with gradual loss of water and the nucleus loses its ability to bind water; thus intradiskal pressure decreases. Further aging or trauma causes a decrease of protein polysaccharide concentration and the disk becomes more fibrous, inelastic, and inert hydrodynamically.

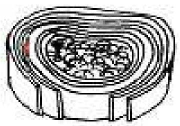

***Figure.21a:*** *Annulus fibrous. Above, Layer concept of annulus fibrous.*

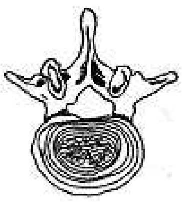

***Figure.21b:*** *Circumferential annular fibres about the centrally located pulpy nucleus (nucleus pulposus).*

Degenerative changes decrease the efficiency of the intervertebral disk (Fig.22). These changes may be due to aging, a genetic precursor, or chemical or microtraumatic factors. The hydrodynamics become impaired.

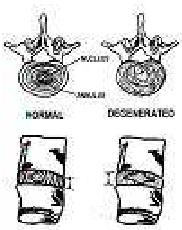


***Figure.22:*** *Disk degeneration. Left, Normal disk with intact nucleus and annular fibres. The space is normal(N). Right, Degenerated disk with the nucleus outside its boundary and fragmented annular fibres and narrowed space (D).*

The disk functions as a hydraulic shock absorber. The pressure within the nucleus pushes the vertebrae apart and annual fibres pull them together (Fig.23). As weight is added to the unit, the vertebral bodies approximate by deforming the nucleus. Upon release of the compressing force, the nucleus regains its resting form. Flexion, extension, and some rotation is permitted by this nucleus deformation. Compression tests have confirmed that forces will fracture the vertebrae before damaging the disk.

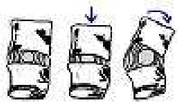

***Figure.23:*** *Left, Normal nonweightbearing disk; Center, Deformation of nucleus reacting to compression; Right, Deformation of nucleus permitting flexion or extension.*

The posterior longitudinal ligament reinforces the posterior aspect of the intervertebral disk. In the lumbar region the ligament tapers to become partial and, thus, affords inadequate protection to the contents of the spinal canal and the intervertebral foramina (Fig.24).

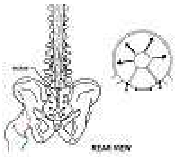

***Figure.24:*** *Inadequacy of the posterior longitudinal ligament in the lower lumbar segment, therefore decreasing the protective effect in the L4, L5, and S1 region. Tight, Disk herniation may bulge into the spinal canal, a.*

Flexion, extension, and rotation is permitted because of the obliquity and the elasticity of the annular fibres. Rotation of the vertebral column is restricted by the limit of extensibility of the annular fibers.

Extensive rotation exceeding this limit may be a contributing force to disk damage, herniation, and the deterioration.

Nutrition of the intervertebral disk remains an enigma. In the neonatal period many small blood vessels penetrate the vertebral end plates and supply the disk. These blood vessels are obliterated in adolescence and the disk becomes avascular. Nutrition of the disk by osmosis has been disproved and the current accepted method of nutrition is by imbibition. This forms a colliod imbibition pump.

As the disk imbibes, its size increases and causes the annular fibres to become taut. Equilibrium is reached by the hydraulic pressure exerted by the vertebral end plates above and below and by the encircling annular fibers.

Diffusion of solutes occurs via the central portion of the end plates and through the annulus (Fig.27). Increased intradiskal pressure probably also forces fluid through minute formina in the end plates. When pressure is released or decreased, fluid returns into the disk by imbibition.

There are numerous marrow spaces immediately under the endochondral plate that connects the bone blood supply to the disk and allows diffusion of the solutes. These spaces are more numerous in the annular region than in the nucleus and more numerous in the posterior position of the disk. This factor possible explains early degeneration of the nucleus and of the posterior aspect of the disk.

Solutes containing glucose and oxygen enter by the way of the end plate and sulfates that from glucosaminoglycans enter by the way of the annulus (Fig.27).

Currently the disk is not considered to have innervation within its substance. Numerous investigators have traced nerves of various stages of myelinization and demyelinization to the periphery of the annulus, but no nerves have been verified to enter within the substance of an intact normal disk.

***Figure.27:*** *Disk nutrition through dissusion. Diffusion of solutes occurs through the central portion of the end plates and through the annulus. Marrow spaces exist between circulation and hyaline cartilage and are more numerous in the annulus than in the nucleus. Glucose and oxygen enter via the end plates. Sulfate to form glucosaminoglycans enters through the annulus. There is less diffusion into the posterior annulus. (B.V. - blood vessels)*

## Posterior Postion:

The posterior portion elements of the functional unit consists of pedcles and laminae which form the circular arch comprising the spinal canal. The posterior spinal arch contains the posterior articular joints of the functional units (Fig.28).

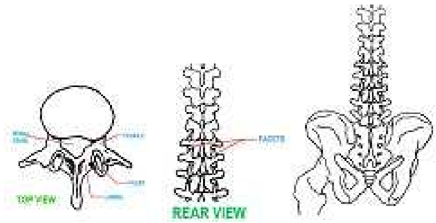


***Figure.28:*** *Posterior view of the lumbar spine depicting the vertical alignment of the posterior articulation (facets) and depicting the small musculature of the lumbar column.*

These facets are composed of articular cartilages on their opposing surface and have a capsule, synovium, and synovial fluid. By their shapes and verticality they articulate on each other to permit specific directions of motion and to deny or modify opposing directions of motion. Becuase of their sagittal vertical plane in the lumbar spine, the facets permit flexion and extension but deny or restrict lateral flexion and rotation (Fig.29). Compared to the anterior joint of the intervertebral disk space, they are not weight bearing. It has been considered that they can support approximately 10 to 12 percent of body weight in the extended spine decreasing to no weight bearing with any significant degree of forward vertebral flexion. In lumbar hyperextension, laterla flexion and rotation can be completely prevented in this posture. The vertebral facets are in complete opposition in a "locked" position. With any degree of forward flexion, separation of the facets occur, thus permitting some degree of laterla flexion and some degree of rotation.

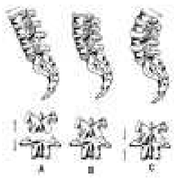

***Figure.29:*** *Facets in the lumbar spine. A, Separation of the facets in forward flexion; B, Opposition of the facets in the physiologic lordotic posture; C, Approximation and opposition of the facets on extension and hyperextension.*

The posterior wall of spinal canal, the anterior wall of the pedicles, and the lamina are covered by the yellow ligament (ligamentum flavum).

The yellow ligament is an elastic logitudinal ligament extending the length of the vertebral column comprised exclusively of yellow elastic fibers. Its function has been considered to be prevention of the redundant capsule from becoming impinged between adjacent joint surfaces during extension of the spine and limitation of capsular bulging into the spinal canal during other movements of the vertebral column.

Completeting the posterior arc of the vertebral body are the transverse processes and the posterior superior spine upon which attach supporting intervertebral ligaments and the intervertebral muscles that activate vertebral column motion.

The intervertebral foramina are formed by two superior and inferior adjacent pedicles. Anteriorly are the vertebrae bodies, the intervertebral disks, and the posterior longitudinal ligament. Posteriorly are situated the facets, their capsules, and the yellow ligament. Through these foramina emerge the nerve roots, their dural sleeve, and the recurrent nerve of Luschka. The nerve roots descend at the cauda equina.