Understanding Spinal Injuries

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Injuries to the spine have puzzled the medical profession for thousands of years and continue to do so. For the attorney involved in cases focusing on spinal injuries, it is important to become acquainted with the component structures of the spinal column, any of which can be the source of painful disability.

"Disease is from old and nothing about it has changed. It is we who change as we learn to recognize what was formerly imperceptible."

—Jean-Martin Charcot (1825-1893)

Since assuming the upright position, human beings have had back problems, making them unique in the animal kingdom. Medical references to low back pain appear in the writings of Hippocrates, the father of medicine, as early as 300 B.C. The term *sciatica* first appeared in literature in the Elizabethan era when Shakespeare had Timon, in the play *Timon of Athens*, act IV, scene I, declare, "Thou cold sciatica, cripple our senators, that their limbs may halt as lamely as their manners!" Neck injuries, on the other hand, seem to be more a product of the 20th century. Initially described during the latter stages of World War I when airplanes were first catapulted off of ships, airmen developed neck pain until a suitable head rest was developed. In 1928, Dr. Harold Crowe first coined the term *whiplash* to describe the "mechanism of injury" to the neck. This term first appeared in medical literature in 1946. The biomechanism of "whiplash" injuries was finally clarified in 1955 after years of incorrect assumptions.[1]

DEFINING THE PROBLEM

Despite its disparaging history, no part of the human anatomy is more frequently injured than the spine. Back pain is the second leading cause of lost time from work, the fifth most frequent cause

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of hospitalization, and the third most common reason for surgical procedures.[2] While estimates vary, at some stage of their lives, 80 percent of all humans will experience low back pain,[3] and 4 percent of these will have chronic back pain.[4] At any given time, it is estimated that 31 million Americans experience back pain; of these, approximately 7 to 8 million actually receive some type of treatment yearly. Of this group, approximately 1 million are unable to work. It has been estimated that 60 percent of the working population of the United States has, at some time or another, suffered from backaches.

The cost has been estimated to be in the billions: Once source estimated treatment cost alone for spinal disorder patients in 1981 to be nearly $13 billion.[5] Extrapolated, those direct costs would have been approximately $23.5 billion in 1990. One can only imagine what the current costs are.

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Moreover, since the advent of the automobile, the incidence of spinal injuries has increased dramatically. Following a motor vehicle accident, 62 percent of patients presenting to the emergency room complain of neck pain.[6] It is clear that this old problem is progressive and will continue to be so in the future. The National Safety Council in 1989 estimated that there were 12.8 million motor vehicle accidents in the United States. A very high percentage of these are rear-end accidents. Wearing seatbelts saves lives, but it causes a greater incidence of neck injuries.[7] Women, probably because of a narrower neck with less muscle mass supporting a head of roughly the same volume compared with men, are more susceptible to cervical spine injuries.[8]

Fortunately, most of these injuries are self-limiting. Fifty percent of the patients recover in two weeks, and 90 percent recover within the first six weeks.[9] Despite the injuries being self-limiting, between 40 and 80 percent of people who experience low back pain have recurrences.[10] Back and neck pain, therefore, are a frequent cause of suffering disability, seriously impairing the quality of human life for countless individuals.

UNSOLVED PROBLEMS

Although neck and back problems have been the subject of medical scrutiny for a long time, one would think that by now the problem of diagnosis and treatment would have been solved. However, it is estimated that in 80 to 90 percent of cases, a pathoanatomic etiology cannot be determined.[11] These injuries are seldom obvious, usually invisible to the casual observer, and they often have few objective findings. One major reason for this problem is no doubt related to the long-held belief that there is a relationship among the vertebral bodies, the intervertebral discs, the bony arch, pedicles and facets, and the contained nerve roots, as being the primary cause of all low back and neck pain. This direction was first charted by Mixter and Barr in 1934.[12] Once this course was charted, it served as the misguided basis for later studies.

Only in the last 20 years, after years of failed treatment, did the medical profession begin focusing on other potential causes of neck and back pain. The myofacial system, which supports the spinal segments, as well as the bony elements themselves, are now considered an integral part of this injury. Important breakthroughs in the role of biochemical and inflammatory factors involved in these injuries, likewise, may ultimately hold the key to improved treatment for this group of refractory injuries. While these new findings lend promise for the future, their significance is still uncertain. To date, there still are very few agreed-upon principles in the treatment of these maladies, and wide regional variation in treatment is the rule.

Frequently, the exact cause of neck and back pain is nonspecific. Further confusion was introduced when the first studies were published demonstrating asymptomatic patients with disc herniations imaged on CT and MRI.[13]

No one definition exists for the entire spectrum of maladies affecting the neck and back. Any component part of the spinal column, including its supporting structures, the numerous joints contained therein, the various ligaments, muscles, as well as the spinal cord and nerve roots, may be the source of painful disability. To understand the nature of the pathological process, it is important to become acquainted with all of these structures, as well as the basic neurophysiology of the spinal cord and peripheral nerves and how they act as major integrating parts of the human body to coordinate motion and perform motor and sensory functions.

THE SUPPORT SYSTEM

The Spine

The spine is an articulated, load-bearing column composed of rigid vertebral bodies and intervertebral discs, controlled and attached by muscles and ligaments. The spinal column's irregularly shaped bones have projections pointed enough to resemble spiny outgrowths, thus giving it one of its common names, "spinal column." It is critical to remember that the spinal column is a series of articulated joints that permit a wide range of motion. It is the property of the spinal column that permits turning and bending in various directions from which its formal name, "vertebral column" (*vertebral* being taken from the Latin *vertere*, meaning "to turn"), is derived. Individual bones of the column are, therefore, vertebrae, and that is how members of our subphylum come to be called vertebrates. The spinal column does not bend sharply at some individual point, such as the elbow, but only slightly at each of a number of points, forming a smooth concavity or convexity. It is this unique quality that retains much of the strength of rigid bones, while at the same time providing for flexibility seen in truly jointed bones.

The spine has multiple curves, which accounts for its tremendous load-bearing ability. The cervical and lumbar regions are in dordosis; the thoracic, sacral, and coccygeal regions are in kyphosis. These curves give the spinal column increased flexibility and shock-absorbing capacity, while maintaining sufficient stiffness and stability at the intervertebral joints. Curvature of the cervical and lumbar regions is caused by the wedge-shaped intervertebral discs.[14] In both the cervical and lumbar regions, the discs are of greater height anteriorly than posteriorly. The spine has at least four biomechanical functions: (1) protection and housing, (2) support, (3) mobility, and (4) control.

Vertebrae

Although the spine contains 33 vertebrae, the seven cervical vertebrae and five lumbar vertebrae account for the majority of injuries seen in personal injury litigation. Each vertebra has an *anterior* and *posterior* component. The anterior part, which is known as the body of the vertebra, serves as the weight-bearing portion of the structure. Posterior elements act to protect the spinal cord and peripheral nerves and restrict excessive motion, but they also are load bearing. The component parts of the posterior structure are (1) the vertebral arch, comprising two pedicles and two lamina (the pedicles connect the arch to the vertebral body); (2) projections or processes attached to the vertebral arch (two transverse processes that are attachment points for muscles and project laterally from each pedicle-lamina junction, and a spinous process, which can be felt underneath the skin in the back and which serves as an attachment point for muscles); and (3) four articular processes, called facets, which determine the direction and degree of motion allowed by each of the vertebral segments. (There are two pairs of these bones, one pair superior and one pair inferior. The adjacent articular facets form interfacetal joints.) While the muscles and ligaments permit flexion, extension, and overall motion, the facet joints primarily restrict the degree of motion, rotation, and shear.

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The diameter of the spinal canal is narrow in the cervical region and widens as it goes down. In the lumbar region, the size of the spinal canal is quite large. This is significant because it allows a central herniated disc that protrudes into the spinal canal in the lumbar region to be tolerated much better than one elsewhere.

Although the basic design of the vertebrae in the different regions is similar, the size and mass of the vertebral bodies increase going from the cervical to the lumbar vertebrae. This is thought to be a mechanical adaptation to the progressively increasing loads to which the lower vertebrae are subjected.[15] The vertebral bodies are about six times stiffer and three times thicker than the discs. There is both a cortical shell and a cancellous core, both of which have different characteristics.

Facet Joints

The facet (apophyseal) joints are part of the posterior vertebra elements and are four in number. The articular facet joints are extensions of the laminae and are covered with hyaline cartilage on their articulating surfaces. These structures are particularly important in resisting torsion and shear, but they also play a role in compression. In fact, they may carry up to 25 to 33 percent of compressive loads, and even more in certain diseased states.[16] These joints are diarthrodial synovial joints. There is also a meniscus in most of the joints. The joint has a cartilaginous articular surface, a fluid-filled capsule, and numerous ligaments surrounding and reinforcing the capsule.

A joint capsule covers the articular facet joints. It has two layers, the outer stratum fibrosum and the inner stratum synovium. The outer layer is innervated but poorly vascularized. The inner layer produces part of the fluid for the synovial fluid.

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Intervertebral Disc

The intervertebral disc is primarily responsible for the flexibility of the spine. The disc permits motion in four directions: (1) translational motion in the long axis of the spine due to the compressibility of the disc; (2) rotary motion about a vertical axis; (3) anteroposterior bending; and (4) lateral bending.[17] The discs in the young adult contribute 20 to 33 percent of total vertebral column height. The disc is bounded above and below by cartilaginous endplates, to which the annular fibers are firmly attached. The endplates are then attached to the body of the vertebra. The cartilaginous endplate is composed of hyaline cartilage that separates the outer two components of the disc from the vertebral body. The entire unit is then ensheathed by the periosteum, which extends over the vertebrae.

The disc is composed of the outer annulus fibrosis and inner nucleus pulposus. The outer annulus retains the disc during bending, while the inner annulus encapsulates the nucleus, whose primary role is to accommodate compression. Much like the meniscus in the knee, only the outer one third to one half of the annulus receives a blood supply from the epidural space. The annulus fibrosis consists of fibroid cartilage with bundles of collagen fibers arranged in a criss-cross pattern, which withstands high bending and torsional loads. The outer layer of fibers blends with the posterior and anterior longitudinal ligaments. The annulus fibrosis, which surrounds the disc, is composed of layered fibrous collagen, much like the layers of an onion. The annulus fibrosis has small branching, unmyelinated nerve fibers buried in the outer one-third to one-half. An injury to the annulus can damage these nerve fibers, which transmit pain sensations through the spinal vertebral nerve to the posterior root ganglion and ultimately to the pain centers in the brain.

The nucleus constitutes two-thirds of the surface area of a disc and is composed of proteoglycan megamolecules, the largest molecules in the human body. The nucleus pulposus, which is the central gel-like material, is composed of colloidal gel (80 to 90 percent water) at birth, which gradually dehydrates with aging. This mucopolysaccharide gel changes in its biochemical characteristics with damage and age. These changes decrease the water-binding capacity of the nucleus. Usually, the nucleus contains between 70 and 88 percent water, which accounts for its resistence to compression. The nucleus receives its nutrients from diffusion of small molecular substances across the vertebral endplates.[18] It is apparent, therefore, that injury to the annulus can lead to loss of nutrition to the nucleus, and subsequent degeneration. The nucleus is capable of imbibing water to a capacity of approximately 250 percent of its weight.[19]

Ligaments

A very complex set of ligamentous support surrounds the spine. In the front, the anterior longitudinal ligament runs from the second cervical vertebrae all the way down to the sacrum. The anterior longitudinal ligament is considered the strongest ligament in the body (with a tensile strength of nearly 3,000 pounds per square inch). On the back of the spinal column is the posterior longitudinal ligament. The posterior longitudinal ligament narrows as it passes the vertebral bodies, and is not attached to them except at the margins. It is also tapered on the sides and thicker in the center. This probably accounts for many posterolateral disc herniations. There are also interspinal ligaments that join adjacent spinous processes above and below.

The ligamentum flavum extends from the anteroinferior border of the laminae above to the posterior border below, and runs the entire length of the spine, to S1. The ligamentum flavum has the highest percentage of elastic fibers of any tissue in the body.[20] It exerts a constant pull on the facet joint capsule, and thus keeps it in its proper location. Its normal elasticity is lost to some extent with aging, and in extreme cases can become calcified, leading to spinal canal stenosis. The ligamentum flavum, which is customarily resected during disc surgery, connects the inside services of the laminae to the adjacent vertebrae. Its principal role is prevention of excessive motion. Unlike muscles, ligaments are passive structures, so their tension depends on their length.

THE SPINAL CORD AND NERVES

The Spinal Cord

The spinal cord occupies the spinal canal and is a direct extension of the brain. It extends from the base of the brain to approximately the level of the second lumbar vertebra, at which point it enlarges and is known as the conus medullaris. It is only about 18 inches long and about one inch wide, and weighs only one ounce. The spinal cord is covered by three linings, called meninges, named the dura, arachnoid and pia. The space between the dura, which is the outer layer, and the bony canal is called the epidural space and is filled with fatty tissue and blood vessels. In the area of the cauda equina, after the termination of the cord proper, the thecal sac envelopes the nerve roots in the lower lumbar segments.

The Spinal Nerves

The spinal nerves, which come from the spinal cord, originally are mixed motor and sensory nerves. The spinal nerve roots emerge from the gray matter of the spinal cord with a number of axons merging together to form one root, similar to a number of wires in a conduit. There are two separate and distinct nerve roots from each spinal nerve. The forward, or anterior, root is called the motor root (ventral). The posterior, or back, portion of the spinal root is called the dorsal root and is sensory. These two roots extend for a short distance before joining together to form a spinal nerve. After the posterior and anterior nerve roots merge to form a spinal nerve in the foramen, which is the opening through which they exit the bony protection of the vertebrae, the nerve becomes a mixed nerve, carrying both motor and sensory impulses. Once the nerve emerges from the foramen, it again splits into posterior and anterior rami.

Lumbosacral Plexus

A number of nerve roots join together in the cervical and lumbar regions to become a plexus. In the lumbar region, the plexus is formed from the anterior primary divisions of the fifth lumbar nerve, part of the fourth lumbar nerve, the first sacral nerve, part of the second sacral nerve, and part of the third sacral nerve. The plexus then gives off the following nerves: superior gluteal, inferior gluteal, and posterior femoral cutaneous, sciatic, and pudendal. The main branch of the lumbosacral plexus is the sciatic nerve, which is the largest nerve in the human body. This nerve actually consists of two separate nerves in one sheath, the common peroneal nerve (posterior tibial), and the tibial nerve. This important nerve supplies motor function to the muscles at the back of the thigh and then divides into the common peroneal and tibial nerves just above the knee. From there, the muscles of the leg below the knee and foot are innervated. This nerve has important sensory functions as well, including most of the skin of the lower leg from the knee down and the foot.

Sinuvertebral Nerves

In the outer one-third of the annulus are buried small, unmylenated nerve fibers.[21] These nerve fibers are microscopic and are immersed in the collagen. The branching nerve fibers attach to a larger nerve called the sinuvertebral nerve (also known as the recurrent nerve of von Luschka). The nerve branches of the sinuvertebral nerve carry pain stimuli to the brain. The sinuvertebral nerve also conveys sensory messages from the posterior longitudinal ligament and thecal sac.[22]

THE SPINAL MOTION SEGMENT

The spine, as noted above, has a compromise in function that affords protection to vital structures while permitting a maximum degree of flexibility. Rather than a rigid column, the spine is a flexible stack of rigid blocks separated by soft-tissue discs. The basic *functional unit* of the spine is the spinal motion segment. The components of the spinal motion segment are adjacent halves of two vertebrae, the interposed disc and articular facet joints, as well as the supporting ligaments, blood vessels, nerves, and muscles.[23] At any one level, the motion segment has three joints: the two facet (zygapophyseal) joints and the intervertebral joint (disc). The motion of the spine is produced by adjacent muscles and is limited by the supporting ligaments and facet joints.

The vertical forces applied to the spine from above are largely dissipated along a horizontal axis by the intervertebral discs. When the three joints are normal, they are anatomically linked and mechanically balanced. Like many other parts of the human body, an injury to part of the motion segment invariably affects the entire unit, and it is for this reason that the parts should not be considered independently of each other. The disc requires normal movement for its nutrition, which cannot occur unless the facets are functioning properly. Additionally, if the facets are damaged, abnormal forces are applied to the annulus, which will cause degeneration over time. The facets also require normal discs which, if they become inelastic, affect normal arthrokinematics.[24] It is therefore important to think in terms of segmental dysfunction because of the intimate mutual dependency of the paired facet joints and the intervertebral joints, as well as the muscles and ligaments, the nerves supplying the segment, the spinal nerves leading from the segment, and the nerve tissue within the vertebral canal at the segment.

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The joints are more vulnerable to injury than adjacent bones. The cervical and lumbar segments, unlike the thoracic spine, have no lateral support and have a considerable ability to flex and extend. During extension, the posterior articulations close, which allows optimal load shearing between the intervertebral disc and the facet joints. Additionally, minimal rotation is possible in extension. In flexion, the posterior articulations are disengaged. The load is then transferred to the anterior column, especially the intervertebral disc. In rotation, the axis of rotation occurs primarily over the disc.[25] As a result, the neck is most vulnerable to injury while in flexion.[26] This flexion, extension, and lateral movement occur with sliding or gliding of these posterior articulations upon each other. The neck and back are both capable of movement in several directions (coupling movements).

Although motion between two vertebrae is limited, there are three planes of motion: (1) flexion and extension; (2) lateral flexion (sidebending); and (3) rotation. There is also some vertical compression and distraction. Differences in the facets account for different motions, such as more rotation in the lumbosacral region.[27] There can also be asymmetry in the facet angles in about 25 percent of the normal population, which can result in early disc degeneration.[28]

In addition to its capacity for mobility, the spine must bear the weight of the upper body. Frequently, this function occurs while the spine is undergoing movement. It is for this reason that the size of the vertebrae increase as they go down, with the lumbar vertebrae being the largest vertebrae of the spine. Thus, the quality of the weight-bearing tissue becomes important as well as the manner in which the weight is carried and shifted. It is the sum of these qualities that determine how efficiently the spine bears its burden.

After adolescence, as previously noted, the nucleus pulposus undergoes changes throughout much of the remainder of an individual's life, finally reaching a state where the original structures are replaced by connective tissue. The disc's primary function is to dampen the longitudinal transmission of forces through the structure. The rotational and anterior gliding of the spine are limited by the apophyseal and facet joints. The elastic ligamentum flavum also assists in resisting forward bending and facilitates extension by virtue of its attachment to the capsule of the facet joint, thus assisting in maintaining its position during movement.

Within the spinal motion segment, a number of structures are pain sensitive. These include the nerve roots, dura, posterior and longitudinal ligaments, the outer one third of the annulus, facet joints, joint capsules, and cancellous bone. Other structures have not been shown, at least to date, to contain pain innervation, including the ligamentum flavum, inner annulus, and nucleus pulposus.[29]

WHY ARE THE NECK AND BACK SO FREQUENTLY INJURED?

This phenomenon has a very simple mechanical explanation. The neck and the back, both quite flexible, are situated between relatively inflexible sections of the spine. The cervical region meets the inflexible dorsal, or thoracic, spine. The dorsal spine attaches to ribs and, consequently, is relatively inflexible. Above the cervical region is the head, which weighs approximately 10 pounds. It is this weight that actually distinguishes the mechanism of entry from a true whip, which does not have this added feature. The low back is bounded by the dorsal spine above and the sacrum, which is fixed to the rigid pelvis, below. With respect to the low back, the greatest axial loads are brought to bear on these lower five segments, which also account for increased risk of injury.[30]

THE EFFECTS OF AGING AND DEGENERATION

Disc Degeneration

The disc, as noted above, like most similar structures in the body, dehydrates with aging. The nucleus, and two-thirds of the annulus, do not have a blood supply and, therefore, do not tolerate injury well. These structures receive nourishment and eliminate waste through a hydrostatic process. The annulus, or wall of the disc, is composed of intertwining elastic fibers. When these fibers tear, the nucleus pulposus herniates through the opening. Sudden extension of the spine can severely damage the posterior aspect of the disc by posterior compression. Sudden flexion of the spine may cause a rupture of the intervertebral disc with anterior compression. An injured disc tends to stretch and fray the annulus. The nucleus pulposus, which is under pressure, tends to bulge into the weakened area. In the uninjured disc, 80 to 90 percent of the weight of the motion complex is borne across the posterior third of the disc. As the disc declines in height from degeneration, the center of biomechanical loading shifts posteriorly. The facet joints then are progressively more loaded, leading to hypertrophy, which may lead to progressive foramina and central canal narrowing.[31]

As people age, their bones and the surrounding soft tissue also become more susceptible to injury because of loss of mass, elasticity, and resiliency. As the disc dehydrates, losing a great deal of its ability to absorb compression, greater loads are put on the joints. These age-related changes occur by the beginning of a person's fourth decade. Even before that, autopsy studies show that disc degeneration begins at 20 to 25 years of age.[32] This process is most likely secondary to the obliteration of the vascular channels, which begins during the second decade. Like the disc, the facet joints naturally degenerate with age. The same autopsy studies mentioned previously found that 90 percent of patients older than 45 had lumbar facet osteoarthrosis.[33]

The disc's nucleus gradually changes from a gel to more of a viscous, fibrous structure. With this comes a resultant decrease in water-binding capacity and a slight increase in collagen content. The posterior annulus gradually becomes more weight-bearing secondary to the loss of structural integrity and function of the nucleus, as well as the increase in lumbar dordosis. Clefts or gaps appear in the posterolateral annulus, and the vascular channels become compromised. By the fourth decade, transformation of the nucleus from a gel to a largely fibrous mass becomes almost complete. The nucleus becomes less distinguishable from the annulus. Radial tears begin to appear in the annulus, and with further progression, the nucleus can herniate. As the annulus weakens and the nucleus loses its ability to withstand compression, added stress is placed on the margins of the vertebral body, resulting in hypertrophic bony reaction with the development of spurs and osteophytes.

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People between the ages of 30 and 50 are more susceptible to an acute herniated disc with its resulting pain syndrome. People of this age are usually more active and the nucleus pulposus still has good volume, therefore exerting horizontal forces on the annulus, which has begun to weaken and form clefts, making it more likely to tear. The posterolateral annulus, which tends to weaken first, is the most frequent site of herniations, probably because the posterior longitudinal ligament is stronger centrally and thinner over the posterolateral disk.

Vertebrae Degeneration

Like the other portions of the spinal motion segment, the vertebrae also degenerate. There is a gradual decrease in cortical bone of 3 percent per decade, and much more than that in postmenopausal women. These changes can affect the load-bearing capacity of the vertebrae.[34] The endplate, the weak point of the disc, is frequently the site of failure when compressive loads become excessive. It gradually demineralizes between the ages of 23 and 40. By age 60, only a thin layer of bone separates the disc from the vascular channels. As this happens, the channels that permit nutrients to get to the disc become obliterated, leading to disc degeneration.[35] By the age of 45, about 60 percent of all persons have spondylitic and arthrotic changes involving the entire motion segment.[36]

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Facet Joint Degeneration

In the lumbar spine, degenerative changes of the facet joints occurs in everyone beyond the third decade. Fortunately for most people, because this process is so gradual, many people have minimal or no symptoms at all. The joint tissues adapt by means of fibrosis, bony hypertrophy, and thus there is little if any inflammation or pain. This would account for the x-ray findings of joint space narrowing with hypertrophic bony changes with no complaints of pain by the patient. When these changes occur quickly, however, the person will probably experience pain and limitations of motion. The posterior elements usually proceed from early degenerative joint disease with articular erosion of the facet surfaces to fibrous dysplasia, loss of normal anatomical relationship of the facets, osteophyte formation (in an attempt to heal capsular injuries), synovial proliferations, and eventually hyper or hypo mobile joints.[37] Additionally, the synovium may become entrapped, as can the meniscoid bodies.[38] With loss of disc space, the superior facet can vertically sublux, leading to pain from the facets themselves or root impingement.[39]

During early phases of degeneration, synovitis frequently occurs. Chronic synovitis and joint effusion can stretch the joint capsule, which may become entrapped in the joint. The cartilage surface can also become damaged by this process. As the posterior elements become unstable, over time osteophytes develop, which eventually can stabilize the motion segment by increasing the load-bearing surface and decrease motion, resulting in a stiff but less painful motion segment. With this bony stabilization a price is paid, and central or lateral stenosis can develop, causing nerve root impingement.

Radiographic Findings

It is not at all unusual to have positive findings on x-rays of patients without symptoms. Between the ages of 20 and 29 years, 13 percent of men will have evidence of spondylosis (arthritis), and by age 70, virtually all males have identifiable findings.[40] In one study of 100 patients referred for MRI without cervical spine symptoms, 57 percent of patients older than 64 were found to have disc protrusions.[41] There is objective disc-space narrowing or osteophyte formation shown on x-rays of 70 percent of men and 50 percent of women aged 55 to 64. There now appears to be ample evidence that trauma to the spine can accelerate the development of cervical spondylosis with degenerative disc disease.[42]

Do Disc Extrusions Spontaneously Resolve?

The number of published studies that have considered this subject is limited, and the patient population small. One study's population consisted of 11 patients with documented extrusions and radiculopathy. These patients were followed over time and then rescanned. The study demonstrated that lumbar intervertebral disc extrusions morphologically changed in a manner consistent with resorption. The exact mechanism was not determined.[43] Theoretically, researchers in this study surmised that when the nuclear material is exposed to the vascular supply of the epidural space and separated from the nutrient supply of the disc, the process of resorption begins. Additionally, cellular elements in the epidural space stimulated by the inflammatory response would promote phagocytosis of the offending nuclear material.

Biochemistry: Inflammation and Chemical Reaction

In addition to mechanical irritation, pain can also be caused by chemical irritation of the nerves. Herniated disc material has been shown to cause an intense inflammatory response. Surgical samples of herniated discs have demonstrated high levels of PLA 2 (phospholipase), a pain enzyme.[44] PLA 2 is a natural substance produced by the body in reaction to injury. When the disc herniates, immune cells accumulate and produce the entire inflammatory cascade. This seems to explain why certain people have a beneficial response to epidural steroids. Many other inflammatory agents have also been isolated in this part of the body, including histamine, bradykinin, serotonin, and prostaglandin E1 and E2. These substances are all known to stimulate nerve endings and thereby cause pain. There is a great deal of research being done in this area, with new findings still being made.

A PERPLEXING MALADY

Injuries to the spine have puzzled the medical profession for thousands of years. Although new information is gathered daily, there is still a great deal to be learned about the pathophysiology of spinal pain.

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