Disk Herniation

As the nucleus pulposus loses its turgor and the elasticity of the anulus diminishes, the disk bulges outward beyond the vertebral body margins, causing bulging of the disk. Herniation of the nucleus pulposus (HNP) through an anular defect causes focal protrusion of the disk material beyond the margins of the adjacent vertebral endplate, resulting in disk herniation. Trauma is the single most common cause of rupture of the nucleus pulposus through the anulus fibrosus. The result is protrusion or extrusion of the disk material into the vertebral canal. This outcome can be caused by a single event or by repeated trauma. Predisposition to degeneration is also a factor. Alterations in the vertebral endplate cause loss of disk nutrition and disk degeneration.

Other potentiating factors include the following:

1. Age
2. Apoptosis
3. Abnormalities in collagen
4. Vascular in-growth
5. Loads placed on the disk
6. Abnormal proteoglycan
7. Obesity
8. Sedentary lifestyle
9. Poor physical fitness

Pathophysiology

Symptoms of HNP are the result of either HNP through a mechanically weak anulus fibrosus or from tearing of the anulus itself. Subsequent radiculopathy can result from nerve root compression or from an inflammatory process affecting nerve roots (neuritis). When the spinal cord is involved at the cervical or thoracic level, myelopathy ensues.

Herniation is thought to be caused by a defect in the anulus fibrosus, most likely the result of excessive stress applied to the disk. The injury most often occurs on the posterior or posterolateral aspect of the disk. Histologic evaluation reveals that, whatever the cause of the tear, the extruded portion always involves material from the nucleus pulposus. The morphology of the anular fiber bundles plays an important role in the propensity for disk herniation on the posterior aspect of the disk. This directs the herniation toward the exiting and traversing nerve roots.

Frequency

Mild bulging of lumbar and cervical disks are common incidental findings in patients older than 20 years. Such bulging is more common in the lumbar region than in the cervical region. The bulging may or may not be clinically significant. Some patients with bulges are symptomatic, whereas others remain totally asymptomatic.

The incidences of cervical radiculopathies by nerve-root level are as follows: C7, 60-70%; C6, 19-25%; C8, 4-10%; and C5, 2%.

Herniation of the inter-vertebral disk may occur in any direction. This is a common condition associated with the increasing wear and tear that occurs with aging. Focal trauma exerted on the inter-vertebral disk is a causal factor.

About 90% of all lumbar disk herniations occur at the L4-5 and L5-S1 levels, about equally. Herniations at the L3-4 disk are subject to infrequent rupture. Nearly 93% occur inside the spinal canal, 3% are predominantly in the intervertebral foramen, and 4% are

extraforaminal or occur far laterally. About 20-30% of all HNPs of the cervical region occur at the C5-6 level; 60-75% occurs at the C6-7 level.

Symptomatic herniation at the thoracic level is relatively uncommon; thoracic HNP accounts for less than 1% of all diskectomies.

Mortality/Morbidity

When untreated, partially treated, improperly treated, or even optimally treated, HNPs may result in severe morbidity, characterized by chronic pain syndrome, segmental paresis, atrophy, reflex changes, sympathetic dystrophy with regional dysautonomia, and sphincter dysfunction.

Herniation of a central disk in the cervicothoracic region results in myelopathy with attended paraparesis, spasticity, hyperreflexia, clonus, sensory disturbance in the legs, and sphincter dysfunction. With herniation of a high cervical central disk, respiratory compromise may occur. This, in addition to complications of immobility and associated intercurrent infections, increases the mortality rate.

Age

HNP may be observed with MRI in 10% of asymptomatic individuals younger than 40 years and in 5% of those older than 40 years. Degenerative disk disease (DDD) is most common after age 40 years.

Anatomy

Disk and ligaments

Each disk is composed of 2 parts: the nucleus pulposus (the inner, central, soft part of the intervertebral disk) and the anulus fibrosus (the thick outer part). A longitudinal ligament attaches to the vertebral bodies and to the intervertebral disks anteriorly and

posteriorly; the cartilaginous endplate of each disk is attached adjacent to the bony endplate of the vertebral body. The anterior longitudinal ligament (ALL) provides a tension band to resist forces applied in extension; it is a stronger ligament than the posterior longitudinal ligament (PLL). The PLL is not as strong as the ALL; it provides a tension band to resist flexion forces. The PLL strongly attaches to the anulus fibrosus. The incidence of tears of the PLL is high among cases of free-fragment disk herniation.

The nucleus pulposus consists of proteoglycan and, specifically, hyaluronic long chains, which have highly hydrophilic branching side chains. They have a strong avidity for water molecules and therefore hydrate the nucleus or the center of the disk.

The anulus fibrosus forms a ring around the nucleus pulposus. It also attaches to the vertebral bodies above and below. As the nucleus pulposus loses its turgor and elasticity, the disk bulges outward beyond the margins of the body of the vertebra.

The anular bands are subdivided into inner fibers and outer Sharpey fibers. The inner fibers are connected to the cartilaginous endplate, whereas the outer fibers are attached to the vertebral body.

A meningeal branch of the spinal nerve, better known as the recurrent sinuvertebral nerve, innervates the area around the disk space. This nerve exits from the dorsal root ganglion and enters the foramen, where it then divides into a major ascending branch and a lesser descending branch.

The disk receives most of its nutrition by diffusion. It has a low metabolic rate. The disk itself is not supplied by lymphatics or blood vessels.

Nomenclature and classification of lumbar disk pathology

The North American Spine Society (NASS), the American Society of Neuroradiology (ASNR), and the American Society of Spine

Radiology (ASSR) are joint task forces overseeing the standardization of the terms used to define conditions of the lumbar disk.
This article reflects the work of those task forces. Although the principles and most of the definitions used in this article could easily be applied to the cervical and dorsal spine, the focus is on the lumbar spine.

Normal disk

The term normal applies to young disks that are morphologically normal, without consideration of the clinical context. This class does not include disks with degenerative, developmental, or adaptive changes that may be considered clinically normal in some contexts (eg, disks that have undergone typical changes associated with aging, scoliosis, or spondylolisthesis would not be considered normal). However, the bilocular appearance of the adult nucleus resulting from the development of a central horizontal band of fibrous tissue is considered a sign of normal maturation.

Degenerative and/or traumatic pathology

Degenerative and/or traumatic changes in the disk represent broad category that includes the subcategories of anular tear, herniation, and degeneration. To characterize disks as degenerative and/or traumatic does not imply that trauma is necessarily a factor or that degenerative changes are necessarily pathologic, as distinct from changes associated with the normal aging process.

The term anular tear or, more properly, anular fissure refers to separations between anular fibers, the avulsion of fibers from their vertebral body insertions, or breaks through fibers that extend radially, transversely, or concentrically so as to involve 1 or more layers of the anular lamellae. The terms tear and fissure reflect the spectrum of such lesions and do not imply that the lesion is the result of trauma.

Degeneration may include any or all of the following: real or apparent desiccation; fibrosis; narrowing of the disk space; diffuse bulging of the anulus beyond the disk space; extensive fissuring (eg, numerous anular tears) and mucinous degeneration of the anulus; defects and sclerosis of the endplates; and the occurrence of osteophytes at the vertebral apophyses. A disk with 1 or more of these degenerative changes can be further classified as spondylosis deformans, which possibly represents changes in the disk associated with the normal aging process, or intervertebral osteochondrosis, which is possibly the consequence of a more clearly pathologic process.

Herniation

Herniation is defined as a localized displacement of disk material beyond the limits of the intervertebral disk space. The disk material may be nucleus, cartilage, fragmented apophyseal bone, anular tissue, or any combination thereof. The endplates of the vertebral body define the disk space cranially and caudally; the outer edges of the vertebral ring apophyses, exclusive of osteophytic formations, define it peripherally.

Localized displacement in the axial (horizontal) plane is classified as focal, in which less than 25% of the disk circumference is involved, or as broad-based, in which 25-50% of the disk circumference is involved. When 50-100% of the circumferential disk tissue extends beyond the edges of the ring apophyses, the disk is classified as bulging; such a condition is not considered a form of herniation. Likewise, diffuse adaptive alterations of disk contour secondary to adjacent deformity, as occurs in cases of severe scoliosis or spondylolisthesis, may not be herniation.

Herniated disks may take the form of protrusions or extrusions, depending on the shape of the displaced material. In cases involving protrusion, the greatest distance in any plane from the edges of the disk material beyond the disk space is less than the distance between the edges of the base in the same plane.

Because the PLL often constrains posteriorly displaced disk material, imaging may portray disk displacement as a protrusion on axial sections and as an extrusion on sagittal sections; in such cases, the displacement should be considered an extrusion.

Herniated disks that occur in the craniocaudal (vertical) direction through a break in the vertebral body endplate are referred to as intravertebral herniations.

Protrusions may be focal or broad based. The distinction is arbitrarily set at 25% of the circumference of the disk. Protrusions with a base less than 25% (90°) of the circumference of the disk are focal. If disk material is herniated, so that the protrusion encompasses 25-50% of the circumference of the disk, it is considered a broad-based protrusion.

Extrusion

A disk is classified as an extrusion if:

> (1) Any distance between the edges of the disk material beyond the disk space is greater than the distance between the edges of the base measured in the same plane.
>
> (2) There is a lack of continuity between the disk material beyond the disk space and the material in the disk space.

Extruded disk material that has no continuity with the disk of origin may be further characterized as sequestrated. A sequestrated disk is a subtype of extruded disk. By definition, a sequestrated disk can never be classified as a protruded disk. Disk material that is displaced away from the site of extrusion, regardless of the presence or absence of continuity, may be called migrated, a term that is useful for interpreting images because it is often impossible to show continuity on imaging.

Containment and continuity

Herniated disk material can be either contained — a term that refers to the integrity of the outer anulus covering the disk herniation — or uncontained. In cases of contained herniation, fluid that is injected into the disk does not leak into the vertebral canal.

Displaced disk fragments are sometimes characterized as free. A fragment should be considered free, or sequestrated, only if there is no continuity of disk material between the fragment and the disk of origin.

The terms, migrated disk and migrated fragment, refer to displacement of disk material away from the opening in the anulus through which the material extrudes. Some migrated fragments are sequestrated, but the term migrated refers only to the position and not to continuity. Regarding the PLL, displaced disk material may be described as subligamentous, extraligamentous, and transligamentous, perforated, subcapsular, or submembranous.

Canal compromise of less than one third of the canal at that section is classified as mild. Compromise of one to two thirds is classified as moderate, and compromise of over two thirds is classified as severe. The same grading system can be applied to foraminal involvement.

Composition of the displaced material may be characterized by terms such as nuclear, cartilaginous, bony, calcified, ossified, collagenous, scarred, desiccated, gaseous, or liquified.

From central to right lateral in the axial (horizontal) plane, the location may be defined as central, right central, right subarticular, right foraminal, or right extraforaminal.

Clinical Details

Radicular pain is characterized as a unilateral, lancinating, dermatomal pain. Such pain is often exacerbated by coughing, sneezing, or Valsalva maneuvers. It is also exacerbated by maneuvers that stretch the affected nerve root.

Passive straight-leg raising leads to stretching of the sacral and lower lumbar roots. Passive flexion of the neck stretches the cervical roots. Spinal movements that narrow the intervertebral foramina (extension and lateral flexion of the neck) can also aggravate root pain. This is common with extradural lesions but is rare with intramedullary lesions.

Clinical signs may include dermatomal hypesthesia or hyperesthesia, segmental paresis, amyotrophy, reflex changes, and fasciculations. In the case of herniation of a lumbar disk, the patient may experience sphincter disturbances in addition to a painful back and radicular pains. Bilateral symptoms and signs suggest that the disk material has protruded centrally; sphincter dysfunction is more likely to be the result of a central herniation than a lateral herniation.

The location of the ruptured disk determines where a person has symptoms. Most ruptured disks are in the lower back and cause low back pain. If the ruptured disk presses on a nerve, pain may be felt in the buttocks, legs, and feet. This pain, which usually affects only 1 leg, is known as sciatica.

L5 root involvement causes weakness in foot and toe dorsiflexion, whereas an S1 lesion leads to depressed or absent ankle jerk and weakness of plantar flexion. In either case, restriction in movement of the spine, local tenderness, paraspinal spasm, and/or a positive Lasègue sign (which is observed on a straight leg-raising test) may be evident. Involvement of the L4 root results in a depressed or absent knee jerk; such involvement may also cause weakness and atrophy of the quadriceps and, occasionally, the adductors.

In the event of cervical HNP, patients may present with neck and radicular arm pain that is exacerbated by neck and head movement. The disk causes referred pain between the scapulae in the upper middle part of the back. Headache originating at the base of the neck is common. Pressure on a nerve may cause numbness and burning or weakness in the arm and hand. Pressure on the spinal cord in the

neck causes symptoms of weakness in the legs, electric shocks down the spine, and numbness or poor coordination; such findings are of concern because they indicate that spinal cord injury is developing.

Lateral herniation of the disk can result in segmental motor, sensory, and/or reflex changes, usually in the involved root level on the affected side. The C6 and C7 roots are more commonly involved. With a more centrally directed herniation, central cord syndrome may develop, resulting in myelopathy, characterized by spastic paraparesis and a sensory disturbance in the legs; myelopathy is sometimes accompanied by impaired sphincter function.

Vertebral pain is characterized by aching pain that is localized to the point of spine involvement. Such pain is a result of the compressive process; it is often accompanied by joint tenderness. Vertebral pain is common with vertebral extradural lesions such as HNP, neoplastic lesions, and inflammatory lesions. Vertebral pain is infrequent or rare with intramedullary or intradural extramedullary lesions.

Central (funicular) pain is common with intramedullary lesions; it is a deep, ill-defined, and painful dysesthesia that is usually distant from the affected spinal cord level. The exact mechanism of such pain remains uncertain, though it is probably related to dysfunction of the spinothalamic tract, relative to the posterior column. Central pain is often of little value in localizing the lesion.

Complications of cervical and lumbar HNP may include the following:

- Intractable neck and back pain
- Intractable radicular pains down the arm or leg
- Muscle contraction headache
- Regional hyperesthesia, hypesthesia, dysesthesia, motor weakness, sensory loss, reflex changes, and/or sympathetic dystrophy
- Sphincter dysfunction
- Myelopathy, paraparesis, and quadriparesis
- Complications of immobility
- Respiratory compromise, even death

Preferred Examination

Preferred examinations for the evaluation of disk herniation include the following: MRI of the spine (lumbosacral, thoracic, or cervical images), bone scanning, and CT scanning of the spine (lumbosacral, thoracic, or cervical images).

Additional tests, when indicated, include assessments of any of the following, alone or in combination: erythrocyte sedimentation rate (ESR), serum glucose level, prostate-specific antigen (PSA) concentration, alkaline phosphatase value, serum protein immunoelectrophoresis result, and urine findings for Bence Jones protein.

Myelography with CT scanning is usually indicated in the following conditions: when surgery is contemplated in cases of spinal stenosis; with lateral recess stenosis; with multiple abnormal disks; with spondylolisthesis; with possible neoplasm; and after severe trauma.

Limitations of Techniques

Regarding limitations of MRI, some individuals with implanted devices (eg, pacemakers) or with metal in their body may not be able to undergo MRI because pacemaker dysfunction and/or electrode heating are possible adverse effects of MRI. Although changing the gradient fields can induce currents in leads, the radiofrequency (RF) pulses are typically the cause of inappropriate pacing. The physician ordering MRI and the MRI staff must determine whether it is safe for the patient to be examined with MRI.

Although conventional radiographs probably show cortical bone better than MRIs do, the bone marrow is best imaged with MRI, and MRI is superior for demonstrating most bone abnormalities. CT is preferred for unstable patients with severe bleeding. MRI may not always be useful for distinguishing between tumor tissue and edema fluid, and it does not depict calcium well when it is present in a tumor.

Severe obesity limits MRI of the spine.

Postoperative scarring and/or edema can limit results of the study.

Other Problems to Be Considered

Infectious etiologies

Diskitis
Epidural, subdural, or intradural abscess

Mechanical etiologies

Cervical stenosis
Cervical zygapophyseal (facet) arthropathy

Metabolic etiologies

Osteomalacia (softening of the bones)

Rheumatologic etiologies

Ankylosing spondylitis
Enteropathic arthritis
Diffuse idiopathic skeletal hyperostosis (DISH)
Polymyalgia rheumatica (PMR)
Reiter syndrome
Traumatic brachial plexopathy

Normal variants and other

Anular tear
Brachial plexitis or plexopathy
Cervical myofascial pain
Cervical spondylosis
Cervical sprain and strain
Complex regional pain syndromes
Conjoint nerve root

Dilated nerve root sleeve
Ependymoma
Facet fracture
Fibromyalgia
Lumbar plexitis or plexopathy
Lumbar spondylosis
Lumbar sprain/strain
Meningioma
Muscle injury
Nerve root avulsion
Neurofibroma
Osteoarthritis
Osteoporosis, primary
Osteoporosis, secondary
Paget's disease
Parathyroid disease
Perineural cysts
Psoriatic arthritis
Radiation-induced brachial plexopathy
Rheumatoid arthritis
Rotator cuff disease
Schwannoma
Thoracic outlet syndrome

Radiography

Findings

In cases of disk bulging, plain radiographs reveal indirect findings of disk degeneration in the form of loss of height of the intervertebral disk, vacuum phenomenon in the form of gas in the disk, and endplate osteophytes. Moderate bulges appear as non-focal protrusion of disk material beyond the borders of the vertebra; this is typically broad based, circumferential, and symmetric.

False Positives/Negatives

In most cases of HNP, plain radiographs of the lumbosacral spine or cervical spine are not needed. Plain radiographs do not reveal disk herniation; they are usually used to exclude other conditions (eg, fracture, cancer, infection). When the clinical condition strongly suggests HNP, plain radiographs can be avoided.

Myelographic findings in patients with HNP include extradural deformity or displacement of the contrast-filled thecal sac. In addition, myelograms may show elevation, deviation, or amputation of the root sleeve and edema of the affected nerve.

When used in routine practice, magnetic resonance (MR) myelography has been shown to be of limited value. In one study, it assisted in establishing a diagnosis in only a small percentage of cases (6%). The technique was of limited additional value in patients with multilevel pathology, and it was of even less value in patients with scoliosis, for whom it was used to help establish the most likely level to account for the pathology.

CT

Findings

In subligamentous herniation, images show a focal, smooth, outward displacement of the disk margin in the spinal canal, in the neural foramen, or lateral to the neural foramen. CT scans may further demonstrate calcification or, less commonly, gas in the herniation.

In disk herniation, CT scans show a soft-tissue mass with effacement of the epidural fat and displacement of the thecal sac. If the fragment is no longer restrained by the PLL but is still in contact with the disk margin, an irregular, lobulated excrescence on the disk margin is seen. A separated disk fragment is often detected in the epidural fat adjacent to the dural sac or sheath of a nerve root. The disk margin

may appear normal. The attenuation of the nuclear fragments of a fragmented disk is usually 80-120 HU.

To achieve optimal results with CT, a localizer image should be obtained at the site of pathology by using relatively thin sections and optimal resolution. A CT-based diagnosis of herniated disk is difficult in patients who have previously undergone laminectomy, because the epidural fat is partially replaced by fibrosis and the surgical scar. Deformity of the dural sac and nerve sheath, along with the bony changes, helps in the diagnosis.

Cervical disk

The uncinate processes project superiorly from the vertebral bodies posteriorly and laterally to the intervertebral disks. With wear and tear, disk degeneration and narrowing of the intervertebral spaces result in an abnormal relationship of the uncinate processes with adjacent vertebral body, resulting in sclerosis and hypertrophy of the uncinate processes. Since the spinal canal is compromised by the degenerating disk, myelopathy results. When a similar process occurs in the neural foramen, radiculopathy is encountered. Cervical epidural space is naturally narrow; therefore, even small disk herniations and protrusions result in dural sac impingement.

Epidural fat that highlights lumbar intervertebral herniation is nearly absent in the cervical disk. In cervical DDD associated with hard disks, CT often reveals the hypertrophied uncinate processes and osteophytes along the disk margin. On CT scans, soft disks are often characterized by the dural sac indentation by the disk, with the disk having attenuation slightly greater than that of the sac.

Thoracic disk

CT is helpful in diagnosing a thoracic disk when the region of interest, determined on the basis of clinical localization, is small. A thoracic disk frequently contains calcium, which is demonstrable on CT scans. A herniated disk may be seen as a clearly defined mass

surrounded by epidural fat lateral to the dural sac. However, if the epidural fat is lacking, the disk appears as a mass of slightly increased attenuation that displaces the dural sac. CT findings vary depending on the amount of epidural fat and subarachnoid cerebrospinal fluid in the thoracic region.

Degree of Confidence

CT has proved to be as good as or even better than myelography alone in the diagnosis of herniated disk. CT scanning with myelography is superior to either one alone.

MRI

Findings

Common findings on MRI

MRI exquisitely delineates HNPs and their relationship with adjacent soft tissues. On MRI, HNPs appear as focal, asymmetric protrusions of disk material beyond the confines of the anulus. HNPs themselves are usually hypo-intense. However, because disk herniations are often associated with a radial anular tear, high signal intensity in the posterior anulus is often seen on sagittal T2-weighted images. On sagittal MRIs, the relationship of HNPs and degenerated facets to exiting nerve roots within the neural foramina is well delineated. In addition, free fragments of the disk are easily detected on MRI.

In cases of disk bulging, early findings on MRI include loss of the normal posterior disk concavity. Moderate bulges appear as non-focal protrusions of disk material beyond the borders of the vertebrae; bulges are typically broad based, circumferential, and symmetric.

A radial tear of the anulus fibrosus is considered a sign of early disk degeneration. It is accompanied by other signs of disk degeneration, such as a bulging anulus, loss of disk height, herniation of the nucleus

pulposus, and changes in the adjacent endplates. Although a radial tear of the anulus fibrosus can be detected as an area of increased signal intensity on T2-weighted and gadolinium-enhanced MRIs, the association between the annular tear on MRIs and the symptomatic disks is unclear.

Gadolinium-based contrast agents have recently been linked to the development of nephrogenic systemic fibrosis (NSF) or nephrogenic fibrosing dermopathy (NFD). The disease has occurred in patients with moderate to end-stage renal disease after being given a gadolinium-based contrast agent to enhance MRI or MRA scans.

NSF/NFD is a debilitating and sometimes fatal disease. Characteristics include red or dark patches on the skin; burning, itching, swelling, hardening, and tightening of the skin; yellow spots on the whites of the eyes; joint stiffness with trouble moving or straightening the arms, hands, legs, or feet; pain deep in the hip bones or ribs; and muscle weakness.

Uncommon findings on MRI

Uncommon HNP findings on MRI include areas of atypical signal intensity and unusual location.

Some HNPs have high signal intensity on T1- or T2-weighted MRI. Vascularized extruded fragments may show ring enhancement after the administration of contrast material. Lesions in unusual locations include extraforaminal HNPs, fragments sequestered posterior to the thecal sac, and lesions located completely outside the canal (far lateral herniations). Atypical migratory disk patterns may also be seen; occasionally, migration occurs down the root sleeve. In rare cases, HNPs penetrate the PLL and extend intradurally.

A strongly enhancing HNP may mimic a neoplasm such as an ependymoma or a tumor of the nerve sheath.

Contrast enhancement does increase the yield, though minimally. Approximately 5% of patients have abnormally enhancing nerve roots consistent with neuritis; in 70% of these patients, such findings are associated with HNP or disk bulges. In the cervical and thoracic spine, contrast enhancement increases epidural conspicuity and improves diagnostic yield. It is particularly useful in delineating foraminal pathology.

In their extensive study of HNPs, Mikhael et al found that lumbar MRI and CT results were both diagnostic in cases of herniated and extruded disks. MRI provided the most information about the degenerative state of the intervertebral disks. MRI was more accurate than CT in depicting small, bulging, and herniated disks without a ruptured anulus, as well as the relation of the migrated fragments of extruded disks to the back of the vertebrae and the thecal sac. In addition, MRI was more accurate than CT in differentiating postoperative epidural fibrotic changes from recurrent herniated and/or extruded disk and in depicting distal spinal cord abnormalities. CT easily depicted laterally herniated lumbar disks. Myelography was the diagnostic study in cases of arachnoiditis.

Weishaupt et al found that positional MRI more frequently demonstrated minor neural compromise than conventional MRI. Positional pain differences were related to position-dependent changes in foraminal size.

Jinkins et al studied the general clinical utility of the first dedicated MRI unit that enabled upright, weight-bearing positional MRI of the spinal column during various dynamic-kinetic maneuvers (kinetic MRI) in patients with degenerative conditions of the spine. Upright, weight-bearing positional MRI is thought by some to be useful.

Three-dimensional (3D) MRI is a relatively new technique for imaging the lumbar region. Hofman et al found that lumbar 3D volume imaging appeared to be at least equivalent to other MRI

protocols. The nerve root was best depicted on volume imaging, and examination time was considerably reduced.

Taneichi et al studied HNPs with gadolinium-enhanced MRI and reported that this technique depicted not only the morphology but also the pathologic changes associated with nerve root compression by herniated disk. Enhanced MRI was performed in 115 patients who were surgically treated for lumbar disk herniation. Nerve root enhancement was seen in 39.1% before surgery and in 58.7% after surgery. Preoperative root enhancement reflected the intensity of radicular pain rather than the degree of neurologic deficits; by contrast, postoperative enhancement was not correlated with radicular symptoms.

Nerve root enhancement represents intraneural edema in the affected nerve root. Enhanced MRI has the potential for identifying an affected nerve root in patients in whom there is a discrepancy between the level of disk herniation and neurologic manifestations.

INTERVENTION

General diagnostic testing and surgery

Diagnostic testing for herniated disk includes MRI, CT, myelography, and plain radiography, either alone or in different combinations, as the occasion demands. Surgery should occur only when objective findings of structural defects are correlated with the patient's symptoms and signs.

Diskography

Diskography consists of injecting contrast medium into the disk and assessing the patient's response to the injection. Reproduction of pain similar to the patient's existing back or neck pain suggests that the disk may be the source. CT performed after diskography is often useful in assessing anatomic changes in the disk and in demonstrating pathology in the disk, including clefts and radial tears.

Early studies indicated that diskography had low specificity, but more recent studies have failed to induce pain in asymptomatic control subjects, suggesting that diskography has utility in identifying patients with diskogenic pain. Pain reproduction during diskography in symptomatic individuals is variable. The incidence of pain reproduction is lower in patients with disk degeneration than in those with posterior tears of the annulus fibrosus or with significant disk bulges.

In essence, when outcomes of fusion procedures are compared, lumbar diskography is sensitive but lacks specificity.

Diskography is recommended only when adequate attempts at conservative therapy and noninvasive diagnostic tests, such as MRI, have failed to reveal the etiology of back pain.

Specific indications for diskography include the following:

(1) Investigation of persistent, severe symptoms when results of other diagnostic tests for identifying the disk that is suspected of being a source of the pain are negative.

(2) Evaluation of abnormal disks, evaluation of recurrent pain from a disk that underwent previous operation, or evaluation of lateral disk herniation.

(3) Evaluation of patients in whom surgery has failed, to determine whether pseudoarthrosis or a symptomatic disk in a posteriorly viewed segment could be the source of pain.

(4) Evaluation of disks before fusion to determine whether the disks of the proposed fusion segment are symptomatic and whether the disks adjacent to this segment can support a fusion.

(5) Evaluation of patients with a confirmed disk herniation as candidates for minimally invasive surgery.

Complications associated with diskography include the following:

(1) Spinal headache

(2) Meningitis

(3) Diskitis

(4) Intrathecal hemorrhage,

(5) Arachnoiditis

(6) Severe reaction to accidental intradural injection

(7) Damage to the disk

(8) Urticaria

(9) Retroperitoneal hemorrhage

(10) Nausea

(11) Seizures

(12) Headache

(13) Increased pain.

No known damage occurs to disks on long-term follow-up after diskography. HNP is not a complication related to diskography. With prophylactic use of antibiotics, the incidence of diskitis is significantly reduced.

The Dallas classification of diskography includes 7 types.

In type 1, the diskogram is normal manometrically, volumetrically, and radiographically and produced no pain. The diskogram/CT scan shows central contrast enhancement in the axial and sagittal projections.

Type 2 is identical to type 1. In addition, pain is reproducible.

Type 3 includes anular tears leading to a radial fissure. This group is subdivided further into types 3a, which is a posterior radial fissure; 3b, in which the fissure radiates posterolaterally; and 3c, in which the fissure extends laterally to a line drawn from the center of the disk tangential to the lateral border of the superior articulating process.

In type 4, once the radial fissure reaches the periphery of the anulus fibrosus, nuclear material may protrude, causing the outer annulus to bulge.

In type 5, when the outer anular fibers rupture, nuclear material may extrude beneath the PLL and come into direct contact with either the dura or a nerve root.

In type 6, the extruded fragment is no longer in continuity with the interspace; such fragments are said to be sequestrated. Manometrically, volumetrically, and radiographically, the diskograms are always abnormal. Familiar pain may be reproduced only if enough pressure is generated against the free fragment so as to stimulate the pain-sensitive structures.

Type 7, which is the end stage of degeneration, involves internal disk disruption characterized by multiple anular tears. The diskograms are abnormal manometrically and volumetrically, and familiar pain may or may not be reproduced. Radiographically, contrast agent usually fills the entire interspace in a chaotic fashion. The diskogram/CT scan shows extravasation of contrast material throughout multiple annular tears.

Other interventions

Other interventions include imaging procedures necessary to aid in the injection procedures and to supplement and enhance already applied active treatment in motion. They include

(1) epidural steroid injections
(2) selective nerve root blocks

(3) facet joint injections

(4) trigger-point injections

Medical Pitfalls

- The most common medical pitfall associated with disk herniation is the failure to diagnose myelopathy.
    - In addition to a herniated nucleus pulposus (HNP) located centrally at the cervical level, myelopathy may be caused by many other conditions that mimic HNP.
    - Potential complications include paraparesis, quadriparesis, respiratory compromise, wheelchair status, and even death.
    - Good clinical acumen, proper use of consultation, judicious use of diagnostic testing, and timely intervention are useful safeguards against this pitfall.
- In the event of acute injury, failure to completely evaluate the integrity and stability of the cervical spine with clinical skill and appropriate imaging studies is a common pitfall.
- Diagnostic procedures do pose a risk of complications, including reaction to the contrast agent, infiltration at the site of injection, superficial thrombophlebitis.
- Adequate skills and their careful application, supplementary use of imaging, proper patient monitoring, and preparatory skills substantially reduce the medical pitfalls.

Special Concerns

- Prevention of herniated disk involves the following measures:
    - Maintaining proper posture
    - Avoiding repetitive cervical and lumbosacral stress
    - Adhering to a healthy lifestyle
    - Proper nutrition
    - Physical activity
    - Losing excess weight
    - Smoking cessation

    - Seeking medical advice in a timely manner when indicated
- Patient education should include the following topics:
    - Basic understanding of lifting mechanics
    - Knowledge of ergonomics
    - Proper nutrition, exercise, and health
    - Avoidance of obesity
    - Proper care of the neck and back
    - Avoidance of precipitating factors
    - Early and timely seeking of medical help

Brachioradial pruritus

Brachioradial pruritus is a condition where itch, burning and/or changed sensation arise in the areas of skin on either or both arms. The most commonly affected area is the mid-arm.

The affected skin may appear entirely normal. Visible changes may arise from rubbing and scratching the affected area. These include purpura and ecchymoses (bruises), hyper-pigmentation (brown marks), hypo-pigmentation (white marks), lichen simplex (a type of eczema) and scarring. There may be changed sensation when this is tested for with pinprick, cotton wool or heat and cold.

Cause of brachioradial pruritus

Brachioradial pruritus is due to nerve damage. It is more often reported in sunny climates such as New Zealand and Australia, than in cooler areas such as the United Kingdom. It has been suggested that long term sun exposure is responsible, as the outer aspects of the arms are most often affected and these are exposed to more sun than the inner aspects of the arms.

However, in many cases, the nerve damage arises in the cervical spine (neck), when it may be due to:

- Cervical vertebral osteoarthritis
- Cervical rib
- Cervical spinal tumour
- Nerve compression by another structure

Treatment of brachioradial pruritus

Treatment is not always successful. Effective measures include the following:

- Sun protection wearing clothing with long sleeves (more effective than sunscreens alone).
- Cooling lotions as required (camphor and menthol).
- Cervical spine manipulation. This must be done by an appropriately qualified health professional.
- Electrical cutaneous nerve field stimulation.
- Capsaicin cream – this depletes nerve endings of their chemical transmitters.
- Local anesthetic creams.
- Amitriptyline tablets at night.
- Anticonvulsant agents including gabapentin.