Update Article

MAGNETIC RESONANCE IMAGING IN FAILED BACK SURGERY SYNDROME

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Abstract

The failed back surgery syndrome (FBSS) is a severe, long-lasting, disabling and relatively frequent (5-10%) complication of lumbosacral spine surgery. Wrong level surgery, inadequate surgical techniques, vertebral instability, recurrent disc herniation, and lumbosacral fibrosis are the most frequent causes of FBSS. The results after repeated surgery on recurrent disc herniations are comparable to those after the first intervention, whereas repeated surgery for fibrosis gives only 30-35% success rates, and 15-20% of the patients report worsening of the symptoms. MRI has allowed a differentiation between these two pathologies for selection of different therapies. Gadolinium enhanced MR is at present the single most sensitive and specific imaging modality available to the neuro radiology imager for the evaluation of the post operative lumbosacral spine in the patient presenting with FBSS. Medical imaging specialists and clinicians need to better understand the origins and means of avoiding the FBSS, to more clearly focus the post operative imaging evaluation and to more successfully link the clinical diagnosis and the imaging findings with optimised patient therapy.

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Introduction

The spinal cord is an elongated axis of neural tissue stretching between the cranio cervical junction to the thoraco lumbar region. Its importance for the somato motor and sensitive functions as well as its role in the autonomic system is vital. The many mechanisms responsible for back and/or lower extremity pain include the nonspecific mechanical or chemical irritation of (a) afferent somatic/sympathetic neural branches (b) spinal nerves in the spinal cord or neural foramen (c) medial neural branches of the posterior primary spinal rami [1,2].

Complicating the diagnosis and treatment of these conditions is the fact that different types of pathology can produce a similar clinical syndrome. Magnetic Resonance Imaging (M.R.I.) has become the modality of choice for evaluating most spinal syndromes since it is innovative and uniquely sensitive to disease. Mass effect, location in relationship to intervertebral disc and relative MR signal intensities are all variables that can aid in differentiation of scar tissue from disc material [3,4,7].

The failed back surgery syndrome (FBSS)

Operative success i.e. surgical correction in low backache has remained unsuccessful so often (10% to 40%) that failed back surgery is now labelled as a syndrome: the failed back surgery syndrome (FBSS)

[5]. FBSS is characterised by post surgical intractable pain in the low back and lower extremity(ies) combined with varying degree of functional incapacitation. The common identifiable causes of FBSS include clinically relevant epidural fibrosis, recurrent/residual disc herniation, post operative spinal infection, sterile arachnoiditis, post surgical pseudomeningocele formation and lateral recess, foraminal or central stenosis that may preexist or follow the spinal surgery [6].

Other less common causes are surgery inadvertently performed on the wrong site or at the incorrect level, direct nerve injury at the time of surgery, chronic mechanical spinal pain like the facet joint diseases, and fusion failure [6]. Other causes could be recurrent or residual symptoms related to anterior spinal disc protrusion, radiculitis, herniation at another spinal level other than that operated upon, facet joint fracture, and spondylolisthesis [1,7-9]. Conditions need to be distinguished from acceptable and expected post operative findings found after successful lumbar surgery.

Examination Techniques

MR images acquired in multiple planes have superior diagnostic potential, because of its greater contrast resolution characteristics. Administration of intravenous paramagnetic contrast agents like Gadolinium leads to differential improvement in contrast resolu-

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tion and improves the diagnostic sensitivity of MR in the evaluation of FBSS,

T2 weighted fast spin echo images are superior to conventional spin echo images in the Lumbosacral spine because of improved image quality resulting from better spatial resolution and reduced motion artefact. Sagittal and axial fast spin echo T2 weighted images are helpful in assessing neural foramen narrowing, central and lateral recess spinal stenosis, hydration status of the intervertebral disc, abnormal signal intensity of the disc and cancellous bone, and signal intensity of abnormal intra-or perispinal soft tissue masses (e.g. disc herniation, epidural scar/abscesses/phlegmon). Sagittal and axial T1 weighted spin echo images obtained before and immediately after the bolus intravenous injection of Gadolinium product are almost imperative in the evaluation of the post operative lumbar spine. Fat-suppression techniques can also be often used after Gadolinium administration since they improve relative intensity and homogeneity of contrast enhancement of epidural fibrosis thereby distinguishing it from recurrent disc herniation [4]. However it makes critical interpretation of possible abnormal post operative intrathecal nerve root enhancement impossible since small degrees of apparently normal nerve root enhancement are observed not infrequently utilising fat suppression techniques. The initiation of MR imaging with approximately two minutes of the gadolinium injection is important because some disc herniations can be somewhat vascularised and therefore may enhance relatively early [5].

The basis of this imaging strategy is that the vessels in the scar tissue are relatively homogeneously distributed, while in disc herniation the vessels are quite heterogeneous or centrally absent. Therefore a markedly heterogeneously or centrally non enhancing epidural mass would be labelled as partially vascularised herniation, while homogeneous enhancement of an epidural process would be termed epidural fibrosis. It should be noted that imaging after 20 to 30 minutes of contrast agent administration is not helpful because many herniations enhance centrally within the delayed time frame.

Intravenously administered gadolinium compounds are an important adjunct to the MR evaluation of the post operative Lumbosacral spine because of their role in the clarification of the probable cause of the post surgical syndrome. Three major indications for gadolinium in the evaluation of the post operative lumbosacral spine are in the elucidation and differentiation of: a) residual or recurrent disc herniation with or

without associated scar formation, b) isolated epidural fibrosis, and c) spinal leptomeningeal, and/or neural inflammation (infectious or aseptic) and/or neural degeneration [5].

If the patient cannot undergo a MR imaging examination a high dose (40-60 grams iodine equivalent) intravenous iodinated contrast enhanced CT study is recommended after a precontrast survey examination. Myelography is helpful for documenting arachnoiditis and its sequelae such as loculations, adhesions and obstruction, but is otherwise not very informative. Computed tomography continues to be the modality of choice for demonstration of ossific or calcific pathologic changes of the post operative lumbosacral spine.

The normal post operative spine

In hemilaminectomy there is partial resection of the neural arch, along with ligamentum flavum removal. Tissue alteration may be minimal if microsurgical techniques have been used. Such changes are usually best appreciated in the axial plane. In laminectomy, the total resection of the spinal lamina and associated ligamentum flavum is performed, in order to provide a surgical pathway for disc removal to relieve spinal canal narrowing. The surgical absence of bone can be best demonstrated on axial T1-weighted images. There is often an associated asymmetry in the muscle fat planes, posteriorly the paraspinal musculature may also be temporarily indistinct secondary to oedema in the subacute phase after surgery. The posterior border of the dural tube margin may expand posteriorly towards the surgical side/laminectomy defect reflecting this relative bony insufficiency. This is an expected finding and does not represent a pseudomeningocele.

In discectomy, often performed in association with the post surgical changes outlined in the foregoing, a partial or complete resection of the degenerated/herniated disc is undertaken. On unenhanced images acquired immediately after surgery, post discectomy changes can mimic the preoperative appearance of disc herniation because of annular disc disruption and epidural tissue oedema.

This renders the outline of the dural sac and intervertebral disc indistinct, and may produce mass effect upon thecal sac. Homogeneous enhancement of this process on MR after intravenous Gadolinium administration, caused by granulation tissue and/or fibrosis, explains the mild regional epidural mass effect seen commonly in post operative imaging of successful lumbar discectomy patients [5]. Studies have shown that between 6 to 18 months after lumbosacral sur-

gery, vertebral endplates produce enhancement in at least 19% patients and enhancement of posterior annulus has been reported in the majority of asymptomatic post operative patients [7].

In surgical spinal fusion, placement of a bone graft across the transverse and articular processes for the purpose of spine stabilisation is carried out. MR imaging of the bony fusion tissue usually demonstrates mixed or generally decreased signal intensity on T2 weighted imaging. The bone graft has a varied MR appearance depending on its site of origin, the extent of trauma to the graft at the time of harvesting, and the degree of vascular infiltration of the graft.

Recurrent disc herniation and epidural scarring

Unfortunately about 30% of anterior epidural or lateral recess scars can be found within close proximity to the disc space, and about 30% can demonstrate mild degrees of mass effect [8,9]. Hence epidural scarring can be confused with recurrent herniated disc on the basis of unenhanced MR alone. The intensity of disc herniations as noted on T2 weighted images is in part related to the type of herniation (i.e. contiguous or sequestered) as well as to the length of time from patient symptom onset or exacerbation of symptoms to the time of imaging. This is because fresh disc herniations desiccate and shrink at variable rates. As a result of these overlaps in imaging characteristics, unenhanced MR imaging has an accuracy of 85% only in the differentiation of epidural scar tissue from herniated disc material. Early central or homogenous enhancement of herniated discs is thought to be related to vascular density. The status of the disc matrix itself (i.e. extracellular space) may also be an important factor. Anterior epidural and lateral recess scar almost always enhances because fibrosis maintains a fairly large extracellular space, regardless of the age of the scar. This is also the likely explanation of the lack of significant change in the mass effect or T2 signal intensity of epidural scars older than 2 months of age. In general the vascular density of scars does not correlate with enhancement grade and regardless of scar site, appears to remain stable after 2 months of inception.

Peridiscal fibrosis is defined as loose, well vascularised connective tissue (i.e. granulation tissue), that is often found partially or completely surrounding a primary or recurrent disc herniation. It contains chondroid elements surrounded by a definable boundary with the disc. The basic histologic difference between peridiscal fibrosis and a vascularised herniation is that chondrocytes are found only in the herniated disc itself and not typically in scar tissue. Although chondroid

metaplasia in scar has been noted, it usually appears in localised congregations, and therefore should be readily distinguished from the uniformly distributed chondrocytes in fibrocartilage (i.e. disc). Herniated disc material associated with peri discal scar increases in size over a period of six weeks to six months [2]. The distinction with regard to MR imaging is important because a well vascularised herniation is more likely to be falsely labeled scar on Gadolinium enhanced study. That is, in exceptional cases a generally vascularised herniation can enhance within minutes of intravenous Gadolinium administration. In most cases however it appears that the centre of the disc herniation will enhance less intensely than the periphery, but only if imaging is completed within 15 to 20 minutes of contrast agent administration (Fig 1 & 2). In a peripherally vascularised disc herniation, the gadolinium gradually seeps into the center of the disc from the surrounding vasculature over time by diffusion, thereby masking its presence on time delayed imaging. False negative interpretations on enhanced MR with regard to a diagnosis of disc herniation attribute to delaying the scan time, past the immediate post injection period. Despite the occasionally confusing patterns of aberrant soft tissue enhancement it is of paramount importance to recognise that because most scars enhanced with intravenous contrast material and most disc herniations do not, the use of IV contrast agents is imperative in computed imaging of the post operative patients in order to clearly differentiate between the two. The accuracy with this technique could be as high as 95 to 100% [8-10]. A large number of patients treated conservatively (non-surgically) have also demonstrated regression of the disc size consequent to resorption of herniated material, with largest herniation decreasing to the greatest degree [11].

Mechanism of contrast enhancement of post operative epidural soft tissue

Intravascular contrast material (e.g. Gadolinium) diffuses through disrupted tight junctions and other areas of endothelial discontinuity into the extracellular space. Although the extracellular space size vascular density and endothelial gap junction status are usually the major determinant of contrast enhancement within a given tissue, intravascular gadolinium cannot easily penetrate the normal disc matrix and therefore rates of diffusion and partition coefficients between fluid compartments may also contribute enhancement grade. In the case of herniated disc, vascular density is believed to be the most important factor with regard to enhancement characteristics.

Fig. 1: Post operative discectomy scarring at L4-5. Sagittal T2 weighted fast spin echo MR image demonstrates increased signal intensity in the posterior outer annulus, the nucleus pulposus and the adjacent vertebral bodies at LV 4-5 (arrows)

Post operative complications

Post operative infection

The onset of progressively severe back pain occurring soon after surgery, especially when accompanied with a persistently elevated erythrocyte sedimentation rate, is suggestive of post operative infection. T2 weighted MR imaging is more sensitive early on than combined bone and gallium radionuclide scanning in the diagnosis of post operative spondylitis and discitis. However, the specificity of the radionuclide studies is expected to be greater than that of MR imaging. Degenerative disease can also be associated with vertebral marrow enhancement after Gd DTPA similar to the features of vertebral oedema [12]. Epidural infection can appear as a homogeneously or heterogeneously enhancing mass within the spinal canal on enhanced T1 weighted images, or it may present as a peripherally enhancing mass with hypointense center representing liquefactive abscess formation [13].

Arachnoiditis

The predisposing factors may be presence of in-

Fig. 2: Sagittal T1 weighted enhanced image obtained 16 minutes after intravenous Gadolinium administration shows that annulus, vertebral bodies and endplates enhance (arrows) although the central portion of the disc does not. This represents an example of extensive postoperative change in the absence of infection.

tradural blood, the onset of perioperative spinal infection, the prior use of oil based myelographic contrast media and the prior intraspinal injection of anaesthetic or anti-inflammatory (e.g. steroids) agents. Myelography and CT myelography usually clearly depict the changes indicative of arachnoiditis [14]. However subtle changes of focal arachnoiditis (i.e. absence of nerve root sheath filling) may mimic the presence of a herniated disc. The three MR imaging patterns that have been described in adhesive arachnoiditis are: a) matted or clumped nerve roots b) an "empty" thecal sac caused by adhesions of the nerve roots to the walls of the thecal sac and c) an intrathecal soft tissue mass with a broad dural base that may obstruct the CSF pathways. [15].

At present the most reliable method of demonstrating the findings of arachnoiditis on MR is the use of unenhanced axial T2 weighted fast spin echo acquisitions. The class of findings of arachnoiditis identified on MR correlate well with identical findings seen on myelography and post myelographic CT. A 92% sen-

sitivity, 100% specificity, and a 99% accuracy has been reported in the diagnosis of moderate to severe arachnoiditis by MR imaging [16].

Post operative radiculitis

The complex sequelae of chronic neural trauma or ischaemia could be the cause of abnormal neurophysiologic changes resulting in clinical radiculopathy that may continue even after the surgical removal of the initial offender i.e. disc herniation [17,18]. Epidural fibrosis may cause tethering of nerve roots leading to traction on the nerve during somatic movements inducing further neuroelectrical stimulus [19].

Spinal nerve roots have a visually intact blood nerve barrier (BNB) on conventional spin echo enhanced MR. On the other hand, the distinction should be noted that there is little or no BNB within the spinal dorsal root ganglia which explains their intense enhancement pattern after intravenous gadolinium administration. With frank compression injury to the spinal nerves and nerve roots, however, this otherwise relatively intact BNB may break down. In symptomatic post operative patients, enhancement of spinal nerve roots after gadolinium administration was demonstrated at, and extending away from, the surgical site in the chronic post operative period i.e. 6-8 months after surgery (Fig 3 & 4). During the first 6-8 months after disc surgery, nerve root enhancement can be seen in the asymptomatic patient, and indicates the state of nerve root repair [20]

Spinal stenosis

Stenosis of the central spinal canal, the lateral recess of the spinal canal and the neural foramen may be a cause of the FBSS. These forms of spinal stenosis

Fig. 3 : Post operative isolated radiculitis. Enhanced axial T1 weighted spin echo image showing intense enhancement of the S1 nerve root/sheath complex (arrow) without associated abnormalities.

may preexist or follow the surgery. Sensitivity and specificity of MR imaging and CT for depicting spinal stenosis are similar to one another (true positive rate of approximately 90%, false positive rate of approximately 20%) [21].

The appearance of lateral recess spinal stenosis on MR is best depicted utilising T2 weighted, fat suppressed axial fast spin echo imaging. Central canal stenosis is well seen with T2 weighted fast spin echo axial acquisitions. Neural foramen narrowing and dorsal nerve root ganglion deformity are best imaged with direct sagittal T1 weighted MR imaging.

Post operative pseudomeningocele

Post laminectomy pseudo meningocele results from either an inadvertent dural tear or from a persistent opening in the dura following intradural surgery. It is a pseudomeningocele because it is not a true arachnoid lined sac. This potential cause of FBSS usually presents as a recurrence of low back pain following an asymptomatic interval of several weeks. There may also be radicular signs and symptoms. CSF signal intensity on all MR sequences, sometimes fluid levels or relative difference in MR signal intensity are seen secondary to blood products or internal debris.

Post operative spondylolisthesis and failed fusion

Fig. 4 : Enhanced sagittal T1 weighted spin echo image showing extensive multi level enhancement of the S1 nerve root (arrows) extending craniad to the level of the conus medullaris of the spinal cord

Post operative spondylolisthesis and failed fusion

Spondylolisthesis secondary to spinal instability from excessive posterior element surgical resection or post operative facet fracture in the absence of a surgical fusion produces similar findings. Spondylolisthesis may be associated with entrapment of nerve roots in the neural foramina. [22]. Stable fusions cause a conversion of red marrow to yellow (fatty) secondary to a decrease in biomechanical stresses. This is manifested as a subchondral region paralleling the vertebral end plates demonstrating relative high signal intensity on T1 weighted images, and isointensity or slightly high relative signal intensity on T2 weighted images.

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