High Lumbar Disc Degeneration
Incidence and Etiology

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Three hundred seventy-nine consecutive magnetic resonance images (MRIs) with dual-echo images of the entire lumbar spine were reviewed by the authors. All 379 patients presented with back pain and/or leg pain; they were interviewed and examined. Pain drawings were completed by all. There were 42 patients (11.1%) with disc pathologies involving T12–L1, L1–2, and/or L2–3 levels. Six patients (1.6%) had isolated disc degeneration and/or herniations limited only to these high lumbar segments. The remaining 36 patients had degenerative changes of the higher discs with variable involvement of the lower lumbar discs. Out of 12 spondylolsthesis of L5 on S1, 7 had high disc pathologies at one or more levels presenting as slipped lesions; more severe high disc lesions were noted in Grade II slips. Isolated high disc degeneration is often associated with pre-existing abnormalities such as end-plate defects, Scheuermann's disease, lumbar vertebra, and so forth, and stressful cumulative work activities such as in construction workers, airplane mechanics, and so forth. High disc degeneration was noted above or below previous fractures. High disc involvement with diffuse changes in lower lumbar spine was more commonly found in ascending fashion in older age groups, and in patients who have had previous lower lumbar spine surgeries, prior fusions in particular. Our findings suggest that altered mechanics are associated with the high lumbar disc pathologies. [Key words: disc degeneration, high lumbar disc, magnetic resonance imaging, altered mechanics]

Discal pathologies involving the proximal levels of the lumbar spine have not been appreciated as well before the clinical use of the magnetic resonance imaging (MRI) scan. Review of literature showed that most lumbar disc herniations are found in the lower levels. Disc herniations at the L1–2 and L2–3 levels were reported in less than 1% of the cases. Of 88 lumbar disc herniations reported by Love et al.12 two were found at L1–2 and one at L2–3 level. In 279 cases of surgically proven disc herniations reviewed by Decker and Shapiro,4 166 or 59.4% were noted at the L5–S1, 103 or 37% were noted at the L4–5, 8 or 2.9% were noted at the L3–4, and 2 or 0.7% were noted at the L2–3 level. Spangfort24 studied 49 publications with a total of 15,235 operations and found that most of the lumbar disc herniations are found at L4–5 (49.8%) and L5–S1 (46.9%). Only 3.3% were in the high lumbar levels (L1–2, L2–3, and L3–4). In his own series of 2,504 operations, 50% were at L5–S1, 47.4% at L4–5, and 2.1% at higher lumbar levels. Kortelainen et al.13 studied prospectively the neurologic symptoms and signs in 403 patients with lumbar disc herniations and sciatica. They were compared with myelographic and operative findings: 56.8% (239)
of the herniations were at the L4–5 level; 40.7% (164) of the herniations were at the L5–S1 level; 1.7% (7) of the herniations were at the L3–4 level; and 0.7% (3) of the herniations were at the L2–3 level.

These studies mentioned previously were published before the clinical application of MRI. These studies reported only disc protrusions or herniations, structural changes seen as extraluminal defects on myelogram, or gross disc pathologies visualized at the time of surgery. Other forms of painful disc abnormalities including degenerative pathologies without protrusions or obvious structural defects were not included. It is well recognized that biochemical changes in the discs precede structural defects, by alteration in the proteoglycan molecules, collagen content, and decrease in water binding capacity. These biomechanical changes may lead to pain and should be viewed in the disc degeneration–herniation spectrum.

Using data from 16 published reports including 600 lumbar discs of 273 cadavers, Miller et al.18 showed that the L4–5 and L3–4 discs were the most frequently degenerated on the average. When radiographic findings were considered, Hu9 observed that L3–4 level showed the most frequent mild changes with osteophytes present in 46% of heavy workers. Severe radiographic changes with significant disc space narrowing and osteophyte formation were most common at the L5–S1 level, in 12.4% of heavy workers. These severe changes were found in 4.4% at the L4–5 level and 2.6% at the L3–4 or higher levels.

The MRI scan has allowed visualization of early degenerative changes within the discs as well as advanced structural changes. By reviewing consecutive MRI scans of patients with back and/or leg pain, the authors showed that the incidence of high lumbar disc herniation and degeneration is more common than previously believed and extrapolated that altered mechanics may be associated with these high disc lesions.

MATERIALS AND METHODS

Three hundred seventy-nine consecutive MRI scans with dual-echo images of the entire lumbar spine were reviewed by the authors. All 379 patients presented with back and/or leg pain to St. Mary's Hospital Spine Center in San Francisco, California in 1987 and 1988. The patients' ages ranged from 14 to 78 years, with a mean age of 37 years. There were 206 males and 173 females. Patients were interviewed and examined. Pain drawings were completed by all. Most patients were given a trial of conservative treatment, including rest, back school, and physical therapy. Magnetic resonance imaging scans were obtained after the patients failed to respond to a course of conservative treatment and when they continued to have clinical presentation suggestive of disc disease such as pain with sitting and forward bending.

Scans from a variety of MRI units were reviewed. Ninety-six percent of the MRI scans were taken with an 0.3-tesla, Resistive Magnet Unit (Fonar 500, Melville, NY) or a Signa 1.5-tesla Super-Conductive General Electric Unit (General Electric, Waukesha, WI). The examination consisted of three sequences. T₁- and T₂-weighted sagittal images from L1–2 to S1 or from T12–L1 to S1 were obtained. The imaging sequences taken in sagittal plane employed a spin-echo technique with Tr 1500 ms/Te 30 ms or Tr 1500 ms/Te 85 ms. These produced T₂-weighted images and highlighted the signal from the...
nucleus pulposus. Axial sections were also obtained from L2 to S1 or from L3 to S1, using the spin-echo technique and a variety of different imaging sequences were used; most, however, were taken with Tr 800 ms/Te 30 ms. In certain cases, axial sections were obtained from T12 or L1 to the lower levels.

Each MRI scan was reviewed by at least two physicians, including one radiologist.

RESULTS

For the purpose of this study the abnormal disc findings on MRI scans are defined as follows:

1. Disc Degeneration presents with low signal intensity. Separation of the annulus fibrosis from the nucleus pulposus is less complete. Severe degeneration presents markedly diminished signal intensity with the annulus and nucleus becoming inseparable. On sagittal images a degenerated disc has decreased height. On T2-weighted images a normal disc has a central region of high signal intensity representing the nucleus pulposus and inner annulus. Decreased signal intensity is seen in the peripheral region, which corresponds to the outer layers of the annulus and the longitudinal ligaments and/or the endplates.

2. Disc Bulge (protrusion) is a form of degeneration. The disc extends beyond the margins of the adjacent end-plates without disruption of the annulus.

3. Disc Herniation is a focal extension of nucleus beyond the margins of the disc into the spinal canal, with the displaced nuclear material in continuity with the parent nucleus pulposus. The herniated disc material may be situated anterior or lateral to the posterior longitudinal ligament, and may displace epidural fat, compress the thecal sac or nerve root. Edema may be present. High disc herniation may cause cord compression.

4. Disc Extrusion presents with displaced nucleus pulposus through disruption of annulus and posterior longitudinal ligament. The herniated or extruded portion of the disc usually has the same signal intensity as the parent nucleus pulposus, with occasional slight hypointense or hyperintense signal.

5. Disc Sequestration presents with free fragment migrated cranially, caudally, or laterally into the neural foramen and completely separated from the parent disc.

Of 379 cases reviewed, there were 244 patients (64.4%) with disc pathologies involving the L4-5 and/or L5-S1 levels. Sixty-seven patients (17.7%) had involvement of L3-4 discs with seven herniations and four isolated disc degenerations. Fifty-six patients had decreased signal intensity in the L3-4 disc with variable degrees of disc protrusions in addition to L4-5 and/or L5-S1 disc involvements.

There were 42 patients (11.1%) with disc pathologies involving T12-L1, L1-2, and/or L2-3 levels. There were 24 men and 18 women with an age range of 27 to 78 years, and mean age of 51.5 years. There were six patients with lesions limited only to the high lumbar region between T12 and L3. The rest of the lumbar spine was normal in each of these six. Two isolated herniations were noted at the L1-2 level, two herniations at the L2-3, one isolated degeneration of L2-3 disc, and one case of T12-L1 and L1-2 disc degeneration. These isolated high lumbar disc pathologies constituted 1.6% (6 of 379) with age range of 28 to 48 years and mean age of 40.7 years. The presence of the high disc herniations were all confirmed on computed tomographic (CT) scan and palpable tenderness over the disc level on physical examination. One patient with L1-2 disc herniation had myelogram and discogram confirmation in addition (Figures 1, 2A, B, C). There was fully concordant pain reproduction on discographic injection at the herniated level. The injections of the adjacent normal discs cranially and caudally were painless.

The two disc herniations at the L1-2 level were at least 5 mm. Two disc herniations at L2-3 level had extruded fragments measuring at least 7 mm. One patient had a 15 mm × 10 mm × 5 mm extruded disc fragment at the T12-L1 level with mild anterior disc protrusion at the L3-4 level.

High lumbar disc degeneration or herniations are often associated with pre-existing or coexisting abnormalities. Of the six patients with isolated high disc lesion, one had evidence of old Scheuermann’s disease and end-plate defects, one had compression deformity of the vertebral body, one had retrolisthesis, and one had a limbus vertebra at the level of the disc involvement. Degenerative changes of the discs were seen on MRI scans above or below previous fractures in two. High disc involvement with diffuse changes in lower lumbar spine was usually found in ascending fashion in patients in the older age group and in patients who have had previous lower lumbar spine surgeries, prior fusions in particular.

Of 12 spondylolisthesis of L5 on S1, 7 had disc pathologies cranially. One large L2-3 disc herniation was noted above a Grade II L5-S1 spondylolisthesis (Figure 3). One extruded L3-4 disc was found above Grade I spondylolisthesis. Significantly degenerated L1-2 and L4-5 discs were noted proximal to a Grade II spondylolisthesis. One patient with isolated disc degeneration at L2-3 level and another at L3-4 level were found in patients with Grade I spondylolisthesis. Diffuse L2 to L5 degenerations were also noted in Grade I spondylolisthesis in two patients.

Sixty-seven percent of patients younger than 50 years of age, with significant high lumbar disc lesions, were involved with more stressful cumulative work activities. There were construction workers, airplane mechanics, laborers, nurses, and radiology technicians who were involved in lifting activities. The rest were sedentary workers. One sedentary worker (banker) began having back and anterior thigh pain after lifting. He was found to have L2-3 disc extrusion on CT and MRI scans.

With high lumbar disc degeneration and/or mild protrusions, symptoms were mostly localized to back pain with tenderness over the involved disc level. With larger disc protrusions, herniations, or extrusions, pain was also found in the groin region or anterior thigh.

Fig 1. Magnetic resonance imaging of isolated L1–2 disc herniation.
Fig 2. Isolated L1–2 disc herniation. A, MRI; B, Myelogram; C, Discogram, fully concordant pain was reproduced only when L1–2 disc was injected.

Straight leg raising test was negative in all six patients with isolated high disc involvement. One patient with disc extrusion at the L2–3 level, and a milder disc protrusion at the L4–5 level, had positive straight leg raising at 45°. Femoral stretch test was positive in one patient with isolated L2–3 extrusion.

Neurologic examinations were essentially normal in most patients with disc degeneration and/or mild bulge. With larger disc protrusions, hemiations, or extrusions in the high lumbar disc levels, decreased sensation was noted in the anterior thighs in two patients, quadriceps weakness in one, and decreased knee reflex in two.

Fig 3. L2–3 disc herniation above a grade II L5–S1 spondylolisthesis.

DISCUSSION

The development of the MRI scan has allowed an excellent noninvasive means of imaging the entire lumbar spine. Its contrast sensitivity and multiplanar images clarify the disc anatomy and structures within or adjacent to the spine. Disc herniation or extension of nucleus pulposus outside the anatomical confines of the disc is well visualized. Magnetic resonance imaging shows the peripheral annulus–posterior longitudinal ligament complex with decreased signal intensity and the inner annulus–nuclear pulposus complex with increased signal intensity, permitting a better definition of disc herniation not seen with other diagnostic studies. Disc degeneration is manifested as decrease in signal intensity on T2-weighted images. Separation of the nucleus from the annulus becomes less distinct as the degeneration progresses. With such improved capabilities, it is not surprising that our MRI survey of back pain patients showed a greater incidence of high lumbar disc pathologies: 11.1% in contrast to less than 1% disc herniations reported in the past. All 379 MRI scans in our study included T1- and T2-weighted sagittal images of the entire lumbar spine contributing to a higher detection rate. Previous surveys with CT scans or other imaging methods involved fewer disc levels.

This study showed that higher lumbar disc involvement with diffuse changes in the lower lumbar spine was more commonly found in ascending fashion in patients in the older age group. This finding is similar to the report by Spangfort [17] who noted “a constant pattern of increased mean age with the level of herniation in the cranial direction” and higher risk of L2–3 and L3–4 disc herniation over 50 years of age. In our study, high disc pathologies were found in patients aged 27 to 78 years, with a mean age of 51.5 years overall, not unlike Spangfort’s report.

In patients with isolated high lumbar disc lesions, ages ranged from 28 to 48 years, with a mean age of 40.7 years. These patients under 50 years of age also had pre-existing or coexisting abnormalities that may
have predisposed the disc to further injury with mechanical stress. In patients in the younger age groups, high lumbar disc lesions were associated with such pathologies as end-plate defects, Scheuermann’s disease, limbus vertebra, previous fractures, retrolisthesis, or segmental instability. With such pre-existing or coexisting defects, these vulnerable high discs are also predisposed to aggravation by stressful cumulative activities such as in construction workers.

Studies have shown association of back pain and mechanical stress such as frequent bending, twisting, and heavy physical activities. Certain activities are probably more stressful to the high lumbar discs and further studies are required to clarify this. Exposure to vibration has been reported to predispose to low-back pain or disc herniations, and may be associated. Risks of back pain may also be greater in sedentary workers, as intradiscal pressure is increased with sitting. Some of the patients in this study were sedentary workers without history of trauma or mechanical stresses as discussed previously.

As noted in previous reports, most authors believe that the clinical symptoms and signs of high lumbar disc herniation are atypical and may not reflect the true level of involvement. The possibility of high disc lesion should be considered in unusual presentations of back and leg symptoms. In a report of 12 cases of upper lumbar disc herniations, Fontanesi emphasized that compressive roots symptoms at L1–2–3 levels present features that are not specific and may be pluriradicular or with atypical referral pattern. Kortelainen et al noted the neurologic picture of high disc herniation to be unreliable and the radiation of leg pain to be misleading. However, the frequency of reflex changes was higher. The patellar reflex was affected in 37% of L2–3 and 43% of L3–4 herniations, in contrast to only 6% of L4–5 and L5–S1 disc herniations. No sensory deficit was found in L2–3 disc herniations. The straight leg raising test was positive in 94% of all herniations, and it was strongly positive at under 30°, more frequently in lower lumbar herniations. The straight leg raising test was less positive in higher lumbar disc herniations.

Since our report included patients with disc degeneration with or without disc protrusions, a spectrum of neurologic findings was observed. Most patients with disc degeneration and/or mild protrusions did not have any neurologic deficit. Larger disc protrusions or herniations in the high lumbar area presented with decreased sensation in the anterior thighs, weak quadriceps, and/or decreased knee reflex, which are more predictable than reported by other authors.

The relatively high incidence of higher lumbar disc pathologies found in patients with spondylolisthesis suggests altered mechanics may be involved. Although 7 had disc abnormalities cranially in 12 spondylolisthesis of L5 on S1, most of these disc abnormalities were incidental findings. We recommend further studies to determine the frequency in larger populations of patients with spondylolisthesis and to clarify the possibility of abnormal mechanics, which may account for the development of skipped disc lesions above spondylolisthesis.

REFERENCES


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Accepted for publication March 1, 1990.