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<tr>
<td>1. Luo X, Pietrobon R, Sun SX, Liu GG, Hey L. Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. <em>Spine</em> 2004; 29(1):79-86.</td>
<td>Review/other</td>
<td>N/A</td>
<td>To estimate total health care expenditures incurred by individuals with back pain in the United States, calculate the incremental expenditures attributable to back pain among these individuals, and describe health care expenditure patterns of individuals with back pain.</td>
<td>Total health care expenditures for back pain in 1998 in the US were $90.7 billion. Patients with back pain had health care expenditures about 60% higher than individuals without back pain. Among back pain patients, at least 75% of service expenditures were attributed to those with top 25% expenditure. These expenditures demonstrated wide variations among individuals with different clinical, demographic, and socioeconomic characteristics.</td>
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<td>2. Patel AT, Ogle AA. Diagnosis and management of acute low back pain. <em>Am Fam Physician</em> 2000; 61(6):1779-1786, 1789-1790.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Review diagnosis and management of acute LBP.</td>
<td>Radiographs and laboratory tests are generally unnecessary, except in the few patients in whom a serious cause is suspected based on a comprehensive history and physical examination. Patients with suspected cauda equina lesions should undergo immediate surgical investigation. Surgical evaluation is also indicated in patients with worsening neurologic deficits or intractable pain that is resistant to conservative treatment. The current recommendation is two or three days of bed rest for patients with acute radiculopathy. The treatment plan should be reassessed in patients who do not return to normal activity within four to six weeks.</td>
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## Low Back Pain
### EVIDENCE TABLE

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<td>4. Jarvik JG, Deyo RA. Diagnostic evaluation of low back pain with emphasis on imaging. <em>Ann Intern Med</em> 2002; 137(7):586-597.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Summary review (1966-2001) of articles relevant to accuracy of clinical and radiographic examination of LBP patients.</td>
<td>Sensitivity for cancer was highest for MRI (0.83 to 0.93) and radionuclide scanning (0.74 to 0.98); specificity was highest for MRI (0.9 to 0.97) and radiography (0.95 to 0.99). MRI was the most sensitive (0.96) and specific (0.92) test for infection. The sensitivity and specificity of MRI for herniated discs were slightly higher than those for CT but very similar for the diagnosis of spinal stenosis. Support for 1994 Agency for Health Care Policy and Research guidelines: symptomatic therapy without imaging for adults &lt;50 years old without evidence of systemic disease; plain radiography and lab tests can reliably rule out systemic disease; and reserve advanced imaging for surgical candidates or strong suspicion of systemic disease.</td>
<td>4</td>
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<tr>
<td>5. Jarvik JG, Hollingworth W, Martin B, et al. Rapid magnetic resonance imaging vs radiographs for patients with low back pain: a randomized controlled trial. <em>JAMA</em> 2003; 289(21):2810-2818.</td>
<td>Experimental</td>
<td>380 total patients: 190 radiograph, 190 rapid MRI</td>
<td>Randomized trial to determine the clinical and economic consequences of replacing spine radiographs with rapid MRI for primary care patients.</td>
<td>Rapid MRIs and radiographs resulted in nearly identical outcomes for primary care patients with LBP. The rapid MRI strategy had a mean cost of $2,380 vs $2,059 dollars for the radiograph strategy.</td>
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<tr>
<td>7. Chou R, Qaseem A, Owens DK, Shekelle P. Diagnostic Imaging for Low Back Pain: Advice for High-Value Health Care From the American College of Physicians. <em>Ann Intern Med</em> 2011; 154(3):181-189.</td>
<td>Review/other</td>
<td>N/A</td>
<td>A report based on a systematic review conducted for a 2007 LBP guideline and a subsequent meta-analysis to help clinicians practice high-value health care by following a more rational and cost-conscious diagnostic approach.</td>
<td>Good evidence indicates that routine back imaging is not associated with clinically meaningful benefits and exposes patients to unnecessary harms, but imaging remains overused. More evidence-based approach to imaging is needed.</td>
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<td>8. Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. <em>Ann Intern Med</em> 2007; 147(7):478-491.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Practice guideline by American College of Physicians and the American Pain Society on diagnosis and treatment of LBP.</td>
<td>Recommendations are mentioned include: Clinicians should not routinely obtain imaging or other diagnostic tests in patients with nonspecific LBP (strong recommendation, moderate-quality evidence). Clinicians should perform diagnostic imaging and testing for patients with LBP when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected on the basis of history and physical examination (strong recommendation, moderate-quality evidence). Clinicians should evaluate patients with persistent LBP and signs or symptoms of radiculopathy or spinal stenosis with MRI (preferred) or CT only if they are potential candidates for surgery or epidural steroid injection (for suspected radiculopathy) (strong recommendation, moderate-quality evidence).</td>
<td>4</td>
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<tr>
<td>9. Bach SM, Holten KB. Guideline update: what's the best approach to acute low back pain? <em>J Fam Pract</em> 2009; 58(12):E1.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Guideline update on acute LBP. Specific recommendations for consistent management of acute LBP in an outpatient office setting are presented.</td>
<td>Grade A recommendations: (based on good-quality patient-oriented evidence): Advise patients to stay active and continue ordinary activity within the limits permitted by pain, avoid bed rest, and return to work early, which is associated with less disability. Consider McKenzie exercises, which are helpful for pain radiating below the knee. Recommend acetaminophen or NSAIDs if medication is necessary. COX-2 inhibitors, muscle relaxants, and opiate analgesics have not been shown to be more effective than NSAIDs for acute LBP. Consider imaging if patients have no improvement after 6 weeks, although diagnostic tests or imaging is not usually required.</td>
<td>4</td>
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<tr>
<td>10. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. <em>J Bone Joint Surg Am</em> 1990; 72(3):403-408.</td>
<td>Review/other</td>
<td>67 patients, 3 reviewers</td>
<td>To prospectively examine MRI results in patients with no history of LBP, sciatica or neurogenic claudication.</td>
<td>Abnormalities on MRI must be strictly correlated with age and any clinical signs and symptoms before operative treatment is contemplated.</td>
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<td>11. Hitselberger WE, Witten RM. Abnormal myelograms in asymptomatic patients. <em>J Neurosurg</em> 1968; 28(3):204-206.</td>
<td>Review/other</td>
<td>300 patients</td>
<td>Report the incidence of myelographic abnormalities in patients who were studied by posterior fossa myelography to establish a diagnosis of acoustic tumor.</td>
<td>Findings consistent with varying degrees of disc abnormality were revealed in 110 examinations (37%). The defect was single in 56 examinations (19%) and multiple in 54 examinations (18%). A lumbar abnormality was present in 71 examinations (24%), and a cervical abnormality in 63 (21%). Defects were found in both the lumbar and cervical areas in 23 examinations (8%).</td>
<td>4</td>
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<td>12. Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. <em>N Engl J Med</em> 1994; 331(2):69-73.</td>
<td>Review/other</td>
<td>98 asymptomatic people, 2 reviewers</td>
<td>To examine the prevalence of abnormal findings on MRI scans of the lumbar spine in people without back pain.</td>
<td>36% of the 98 asymptomatic subjects had normal disks at all levels. With the results of the two readings averaged, 52% of the subjects had a bulge at least one level, 27% had a protrusion, and 1% had an extrusion. 38% had an abnormality of more than one intervertebral disk. On MRI examination of the lumbar spine, many people without back pain have disk bulges or protrusions but not extrusions. Given the high prevalence of these findings and of back pain, the discovery by MRI of bulges or protrusions in people with LBP may frequently be coincidental.</td>
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<td>13. Wiesel SW, Tsourmas N, Feffer HL, Citrin CM, Patronas N. A study of computer-assisted tomography. I. The incidence of positive CAT scans in an asymptomatic group of patients. <em>Spine</em> 1984; 9(6):549-551.</td>
<td>Review/other</td>
<td>52 studies from control population and 6 scans from patients with surgically proven spinal disease, 3 blinded reviewers</td>
<td>To assess abnormal CT scans in patients with no history of back pain or sciatica.</td>
<td>Irrespective of age, 35.4% (26.6%, 51.0%, and 31.3%) were found to be abnormal. Spinal disease was identified in an average of 19.5% (23.8%, 22.7%, and 12.5%) of the under 40-year-olds, and it was a herniated nucleus pulposus in every instance. In the over 40-year-old age group, there was an average of 50% (29.2%, 81.5%, and 48.1%) abnormal findings, with diagnoses of herniated disc, facet degeneration, and stenosis occurring most frequently.</td>
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2011 Review

Davis

Page 4
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<td>15. Staiger TO, Paauw DS, Deyo RA, Jarvik JG. Imaging studies for acute low back pain. When and when not to order them. <em>Postgrad Med</em> 1999; 105(4):161-162, 165-166, 171-162.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Review appropriate imaging studies for acute LBP and when not to order imaging studies.</td>
<td>No results stated.</td>
<td>4</td>
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<td>17. Florida medical practice guidelines for low back pain or injury. Tallahassee, Fla.: State of Florida Agency for Health Care Administration; 1996.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Guidelines/algorithms for evaluation of all patients with LBP or injury using multidisciplinary panel of experts involved in diagnosis and treatment of LBP.</td>
<td>Inclusive algorithms for diagnosis and treatment options.</td>
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<td>19. Arana E, Royuela A, Kovacs FM, et al. Lumbar spine: agreement in the interpretation of 1.5-T MR images by using the Nordic Modic Consensus Group classification form. <em>Radiology</em> 2010; 254(3):809-817.</td>
<td>Observational</td>
<td>53 patients, 5 reviewers from 3 hospitals twice interpreted lumbar MR examination</td>
<td>To evaluate intra- and interobserver agreement for the interpretation of lumbar 1.5-T MR images in a community setting.</td>
<td>Endplate erosions and spondylolisthesis were observed in &lt;10% of images. Intraobserver reliability was almost perfect for spinal stenosis; substantial for Modic changes, Schmorl nodes, disk degeneration, annular tears, and disk contour; and moderate for osteophytes. Interobserver reliability was moderate for Modic changes, Schmorl nodes, disk degeneration, annular tears, and disk contour; fair for osteophytes; and poor for spinal stenosis. In conditions close to those of clinical practice, there was only moderate interobserver agreement in the reporting of findings at 1.5-T lumbar MR imaging.</td>
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<td>20. Jarvik JG, Haynor DR, Koepsell TD, Bronstein A, Ashley D, Deyo RA. Interreader reliability for a new classification of lumbar disk disease. <em>Acad Radiol</em> 1996; 3(7):537-544.</td>
<td>Observational</td>
<td>34 consecutive patients, 3 blinded readers</td>
<td>To determine inter-reader reliability for a new classification of lumbar disk disease.</td>
<td>Weighted kappa values showed fair-to-moderate agreement. Kappas for the dichotomous decision of extrusion present or absent were more variable, ranging from 0 to .78. Major disagreements (greater than a single category) occurred with 6.2% of all comparisons and in 10/34 volunteers; five involved extrusions. Overall, readers achieved moderate agreement for this new nomenclature. However, agreement for the presence or absence of an extrusion was less reliable.</td>
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<tr>
<td>21. Lurie JD, Tosteson AN, Tosteson TD, et al. Reliability of magnetic resonance imaging readings for lumbar disc herniation in the Spine Patient Outcomes Research Trial (SPORT). <em>Spine (Phila Pa 1976)</em> 2008; 33(9):991-998.</td>
<td>Observational</td>
<td>60 MRI, 58 studies in ratings analysis, 50 studies in analysis of quantitative measurement, 4 independent readers</td>
<td>To determine the intra- and inter-reader reliability of MRI parameters relevant to patients with intervertebral disc herniation, including disc morphology classification, degree of thecal sac compromise, grading of nerve root impingement, and measurements of cross-sectional area of the spinal canal, thecal sac, and disc fragment.</td>
<td>Inter-reader reliability was substantial for disc morphology [overall kappa 0.81 (95% CI, 0.78, 0.85)], moderate for thecal sac compression [overall kappa 0.54 (95% CI, 0.37, 0.68)], and moderate for grading nerve root impingement [overall kappa 0.47 (95% CI, 0.36, 0.56)]. Quantitative measures showed high intraclass correlation coefficients of 0.87 to 0.96 for spinal canal and thecal sac cross-sectional areas. Measures of disc fragment area had moderate intraclass correlation coefficients of 0.65 to 0.83. Mean absolute differences between measurements ranged from approximately 15% to 20%. Classification of disc morphology showed substantial intra- and inter-reader agreement, whereas thecal sac and nerve root compression showed more moderate reader reliability. Quantitative measures of canal and thecal sac area showed good reliability, whereas measurement of disc fragment area showed more modest reliability.</td>
<td>2</td>
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<tr>
<td>22. Carragee E, Alamin T, Cheng I, Franklin T, van den Haak E, Hurwitz E. Are first-time episodes of serious LBP associated with new MRI findings? <em>Spine J</em> 2006; 6(6):624-635.</td>
<td>Observational</td>
<td>200 total patients; 51 had 67 MR scans, 2 independent and blinded readers</td>
<td>Prospective observational study to determine if new and serious episodes of LBP are associated with new and relevant findings on MRI.</td>
<td>Findings on MRI within 12 weeks of serious LBP inception are highly unlikely to represent any new structural change. Most new changes (loss of disc signal, facet arthropathy, and end plate signal changes) represent progressive age changes not associated with acute events. Primary radicular syndromes may have new root compression findings associated with root irritation.</td>
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* See Last Page for Key

2011 Review

Davis

Page 6
### Low Back Pain

#### EVIDENCE TABLE

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Type</th>
<th>Patients/Events</th>
<th>Study Objective (Purpose of Study)</th>
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<td>23. Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR. Degenerative disk disease: assessment of changes in vertebral body marrow with MR imaging. <em>Radiology</em> 1988; 166(1 Pt 1):193-199.</td>
<td>Review/other</td>
<td>474 consecutive patients</td>
<td>Review of lumbar spine imaging studies for vertebral marrow end plate changes with degenerative disk disease.</td>
<td>Type 1 changes evolve to type 2 (5/6), and Type 2 changes were stable (n=10) over 2-3 years. These signal intensity changes appear to reflect a spectrum of vertebral body marrow changes associated with degenerative disk disease.</td>
<td>4</td>
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<tr>
<td>24. Jarvik JG, Hollingworth W, Heagerty PJ, Haynor DR, Boyko EJ, Deyo RA. Three-year incidence of low back pain in an initially asymptomatic cohort: clinical and imaging risk factors. <em>Spine</em> 2005; 30(13):1541-1548; discussion 1549.</td>
<td>Observational</td>
<td>148 Veterans Affairs out-patients</td>
<td>Prospective cohort study of randomly selected Veterans Affairs out-patients without baseline LBP to determine predictors of new LBP as well as the 3-year incidence of MRI findings.</td>
<td>High incidence of LBP (67%) during follow-up. Strongest baseline predictor of LBP was depression. Central spinal stenosis and nerve root contact had highest hazard ratio (nonsignificant). The incidence of new MRI findings was low, with the most common new finding being disc signal loss in 11 (9%) subjects. All five subjects with new disc extrusions and all four subjects with new nerve root impingement had new pain. Depression is an important predictor of new LBP, with MRI findings likely less important.</td>
<td>3</td>
</tr>
<tr>
<td>25. Kjaer P, Korsholm L, Bendix T, Sorensen JS, Leboeuf-Yde C. Modic changes and their associations with clinical findings. <em>Eur Spine J</em> 2006; 15(9):1312-1319.</td>
<td>Review/other</td>
<td>412 patients</td>
<td>To determine if the clinical findings differ in people with Modic changes as compared to those with only degenerative disc findings or none at all in a population based sample of 40 year old Danes.</td>
<td>Persons with disc degeneration and Modic changes had more significant back pain reporting profile than those with disc degeneration or with neither disc degeneration nor Modic changes.</td>
<td>4</td>
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<td>27. Modic MT, Herfkens RJ. Intervertebral disk: normal age-related changes in MR signal intensity. <em>Radiology</em> 1990; 177(2):332-333; discussion 333-334.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Commentary on implications of disk intensity related to aging and degeneration.</td>
<td>Authors not convinced that a degenerating disk can be distinguished on MRI from an aging disk.</td>
<td>4</td>
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* See Last Page for Key

2011 Review

Davis
Page 7
<table>
<thead>
<tr>
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<td>29. Friedrich KM, Nemec S, Peloschek P, Pinker K, Weber M, Trattnig S. The prevalence of lumbar facet joint edema in patients with low back pain. <em>Skeletal Radiol</em> 2007; 36(8):755-760.</td>
<td>Review/other</td>
<td>145 consecutive patients</td>
<td>Retrospective study to assess the prevalence of lumbar facet joint edema in patients with LBP using MRI.</td>
<td>In 21/145 patients (14%) edema was found at the facet joints: in 52.4% at L4/5, in 19.0% at L5/S1, in 14.3% at L4/5 and L5/S1, in 9.5% at L3/4 and L4/5, and in 4.8% at L3/4. The agreement between the change in pain score and intensity of edema within the follow-up group was “almost perfect” (kappa = 0.81). Kendall’s tau coefficient was 0.91, indicating high agreement. Sagittal short-tau inversion recovery images detect facet joint edema in 14% of patients with LBP. This fact may be useful for planning treatment including facet joint injections.</td>
<td>4</td>
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<td>30. Williams AL, Gornet MF, Burkus JK. CT evaluation of lumbar interbody fusion: current concepts. <em>AJNR Am J Neuroradiol</em> 2005; 26(8):2057-2066.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Review of surgery, instrumentation, and imaging of interbody fusion.</td>
<td>CT provides better evaluation of fusion progression and status than dynamic radiography and is becoming the preferred method of monitoring patients who have undergone interbody fusion.</td>
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<td>31. Jackson RP, Cain JE, Jr., Jacobs RR, Cooper BR, McManus GE. The neuroradiographic diagnosis of lumbar herniated nucleus pulposus: II. A comparison of computed tomography (CT), myelography, CT-myelography, and magnetic resonance imaging. <em>Spine</em> 1989; 14(12):1362-1367.</td>
<td>Observational</td>
<td>59 patients</td>
<td>To prospectively compare the accuracy of CT, myelography, CT-myelography and MRI for the diagnosis of lumbar herniated nucleus pulposus.</td>
<td>MRI was the most accurate test (76.5%) compared with CT-myelography (76.0%), CT (73.6%), and myelography (71.4%). False positive rate was lowest for MRI (13.5%) followed by myelography (13.7%), CT (13.8%), and CT-myelography (21.1%). False negative rate was lowest for CT-myelography (27.2%) followed by MRI (35.7%), CT (40.2%), and myelography (44.1%). In that subset of 19 patients who had prior surgery, myelography was the most accurate means of diagnosing lumbar herniated nucleus pulposus (88.8%), followed by MRI (83.3%), CT-myelography (78.4%), and CT (72.6%). The false positive rates in these patients were 11.6% for myelography, 13.2% for MRI, 14.5% for CT, and 16.4% for CT-myelography; the false negative rates were 22.7% for MRI, 24.4% for myelography, 29.5% for CT-myelography, and 47.7% for CT. MRI compares very favorably with other currently available imaging modalities for diagnosing lumbar herniated nucleus pulposus. Authors recommend MRI as the procedure of choice for the diagnosis of most lumbar disc herniations.</td>
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<td>32. Kent DL, Haynor DR, Larson EB, Deyo RA. Diagnosis of lumbar spinal stenosis in adults: a metaanalysis of the accuracy of CT, MR, and myelography. <em>AJR</em> 1992; 158(5):1135-1144.</td>
<td>Review/other</td>
<td>14 total studies: 2 MRI, 9 only CT, 3 CT and MRI, 6 included in myelography</td>
<td>Meta-analysis of CT, MRI, and myelographic studies to evaluate the diagnosis of lumbar spinal stenosis in adults without prior surgery.</td>
<td>Sensitivity ranged from 0.81 to 0.97 for MRI, from 0.70 to 1.0 for CT, and from 0.67 to 0.78 myelography. In asymptomatic patients, abnormal findings appeared on CT or MRI in 4-28% of cases and were more common in the elderly. Published studies of the value of CT and MRI for the diagnosis of lumbar stenosis lack methodologic rigor and do not permit strong conclusions about the relative diagnostic accuracies of these procedures. For the present, the choice between MR or CT depends on issues such as costs, reimbursements, access to equipment, skill of radiologists, and patient safety.</td>
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# Low Back Pain

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<td>33. Modic MT, Masaryk T, Boumphrey F, Goormastic M, Bell G. Lumbar herniated disk disease and canal stenosis: prospective evaluation by surface coil MR, CT, and myelography. <em>AJR</em> 1986; 147(4):757-765.</td>
<td>Observational</td>
<td>60 patients</td>
<td>Prospective study to compare the results of surface coil MRI with CT and/or myelography without reference to either the clinical information or other imaging observations. Findings were then compared with the surgically confirmed pathology.</td>
<td>86.8% agreement between the MRI and CT studies in all patients at 151 levels and 87.2% agreement between MRI and myelography at 218 levels. At the operative levels, there was 82.6% agreement between MRI and surgical findings for both type and location of disease; 83% agreement between CT and surgical findings; and 71.8% agreement between myelography and surgical findings. 92.5% agreement when MRI and CT were used jointly and 89.4% agreement when CT and myelography were used jointly. Results of study indicate that a technically adequate MRI was equivalent to CT and myelography in the diagnosis of lumbar canal stenosis and herniated disk disease. CT and MRI can be complementary studies, and surface coil MR can be viewed as an alternative to myelography.</td>
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<td>34. Shafaie FF, Wippold FJ, 2nd, Gado M, Pilgram TK, Riew KD. Comparison of computed tomography myelography and magnetic resonance imaging in the evaluation of cervical spondylotic myelopathy and radiculopathy. <em>Spine</em> 1999; 24(17):1781-1785.</td>
<td>Observational</td>
<td>20 patients</td>
<td>Cross-sectional retrospective radiologic study to establish concordance rates between interpretations of CT myelography and MRI in patients with degenerative cervical spine disease. Study blindly and randomly evaluated cervical CT myelography and MRI.</td>
<td>Agreement for interpretation of the discovertebral junction occurred in 144 of 240 sites (60%), indicating only moderately good intermethod concordance (kappa = 0.44). Intermethod agreement on the characterization of facet joint disease was only moderately good (143 of 160 sites; 89.4%; kappa = 0.52), and on characterization of lateral recess disease was poor (125 of 160 sites; 78.1%; kappa = 0.20). On degree of spinal canal compromise, there was agreement within one grade in 199 of 240 sites (82.9%; kappa = 0.42). Intermethod agreement on neural foraminal encroachment and cord size was only moderately good (kappa = 0.42 and 0.46, respectively). CT myelography and MRI is only moderately good, with discrepancies noted especially in the differentiation of disc and bony pathology.</td>
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<td>35. Manchikanti L, Glaser SE, Wolfer L, Derby R, Cohen SP. Systematic review of lumbar discography as a diagnostic test for chronic low back pain. <em>Pain Physician</em> 2009; 12(3):541-559.</td>
<td>Review/other</td>
<td>69 studies considered for inclusion, 2 reviewers</td>
<td>Systematic review of the lumbar provocation discography literature to assess the diagnostic accuracy of lumbar discography.</td>
<td>Lumbar provocation discography performed according to the International Association for the Study of Pain (IASP) criteria with control disc(s) with minimum pain intensity of 7/10, or at least 70% reproduction of worst pain (ie, worst spontaneous pain of 7 = 7 x 70% = 5) may be a useful tool for evaluating chronic lumbar discogenic pain. Discography is an important imaging and pain evaluation tool in identifying a subset of patients with chronic LBP secondary to intervertebral disc disorders.</td>
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<td>36. Carragee EJ, Lincoln T, Parmar VS, Alamin T. A gold standard evaluation of the &quot;discogenic pain&quot; diagnosis as determined by provocative discography. <em>Spine (Phila Pa 1976)</em> 2006; 31(18):2115-2123.</td>
<td>Observational</td>
<td>32 patients with LBP and a positive single-level low-pressure provocative discogram, 34 patients (unstable spondylolisthesis)</td>
<td>Prospective study to investigate the hypothesis that provocative discography by strict criteria accurately identifies a LBP illness due to a primary disc lesion.</td>
<td>In the control-spondylolisthesis group, 23/32 patients (72%) met the highly effective success criteria compared with 8/30 in the presumed discogenic pain cohort (27%). The proportion of patients who met the “minimal acceptable outcome” was 29/32 (91%) in the spondylolisthesis group and 13/30 (43%) in the presumed discogenic pain group. Adjusting for surgical morbidity and dropout failure, by either criteria of success, the best-case PPV of discography was calculated to be 50% to 60%. Positive discography was not highly predictive in identifying bona fide isolated intradiscal lesions primarily causing chronic serious LBP illness.</td>
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## Low Back Pain
### EVIDENCE TABLE

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<tr>
<td>37. Manchikanti L, Singh V, Pampati V, et al. Provocative discography in low back pain patients with or without somatization disorder: a randomized prospective evaluation. <em>Pain Physician</em> 2001; 4(3):227-239.</td>
<td>Observational</td>
<td>50 total patients; 25 patients without somatization disorder and 25 patients with diagnosis of somatization</td>
<td>Randomized prospective evaluation to determine value of provocative discography in LBP patients with or without somatization disorder.</td>
<td>Results showed positive provocative discography in 46% of the patients in the somatization group compared to 54% in the non-somatization group; in 46% of patients with depression compared to 54% of patients without depression; in 15/30 patients with generalized anxiety disorder, in 11/20 patients without generalized anxiety disorder; and in 42% of patients with combined somatization and depression, with negative discography in 58% of the patients. Provocative discography provides similar results in patients with or without somatization, with or without depression, with somatization but with or without depression or with other combinations of the psychological triad of somatization disorder, depression, and generalized anxiety disorder.</td>
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</tr>
<tr>
<td>38. Shah RV, Everett CR, McKenzie-Brown AM, Sehgal N. Discography as a diagnostic test for spinal pain: a systematic and narrative review. <em>Pain Physician</em> 2005; 8(2):187-209.</td>
<td>Review/other</td>
<td>71 studies</td>
<td>To systematically assess the quality of clinical studies evaluating the diagnostic accuracy of discography with respect to chronic spinal pain.</td>
<td>Evidence is strong for the diagnostic accuracy of discography as an imaging tool. Evidence is also strong for the ability of discography to evoke pain. There is strong evidence supporting the role of discography in identifying that subset of patients with lumbar discogenic pain. There is moderate evidence supporting the role of discography in identifying a subset of patients with cervical discogenic pain. There is limited evidence supporting the role of discography in identifying a subset of patients with thoracic discogenic pain. Discography is a useful imaging and pain evaluation tool in identifying a subset of patients with chronic spinal pain secondary to intervertebral disc disorders.</td>
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### Low Back Pain

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<td>39. Thompson KJ, Dagher AP, Eckel TS, Clark M, Reimig JW. Modic changes on MR images as studied with provocative diskography: clinical relevance—a retrospective study of 2,457 disks. <em>Radiology</em> 2009; 250(3):849-855.</td>
<td>Observational</td>
<td>736 patients (2,457 disks)</td>
<td>Retrospective study to assess the value of vertebral body endplate signal intensity (Modic) changes on MRI in predicting a painful disk, with provocative diskography as the reference standard. Each disk was assigned a Modic subtype: type 0, normal; type 1, nonfatty high signal intensity; type 2, fatty; and type 3, sclerosis.</td>
<td>Type 1 changes (n = 155) had a high PPV (0.81; 95% CI, 0.74, 0.87) for a provocative discogram. Type 2 changes (n = 126) had a lower PPV (0.64; 95% CI, 0.55, 0.72) for a positive discogram. Type 3 changes (n = 21) had a PPV (0.57; 95% CI, 0.34, 0.78) that was not significant for a positive discogram. The PPV of an endplate with a type 1 change (hereafter, type 1 endplate) for a tear in the annulus fibrosis of the disk was also insignificant (0.14; 95% CI, 0.09, 0.20). A similar analysis between a type 1 endplate and the presence of a disk herniation (PPV, 0.26; 95% CI, 0.19, 0.34) and between a type 1 endplate and vertebral body spondylolisthesis (PPV, 0.28; 95% CI, 0.20, 0.35) were significant. Type 1 signal intensity changes on MRI have a high PPV in the identification of a pain generator.</td>
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<td>40. Masci L, Pike J, Malara F, Phillips B, Bennell K, Brukner P. Use of the one-legged hyperextension test and magnetic resonance imaging in the diagnosis of active spondylolysis. <em>Br J Sports Med</em> 2006; 40(11):940-946; discussion 946.</td>
<td>Observational</td>
<td>71 patients</td>
<td>Prospective cohort to determine whether the one-legged hyperextension test can assist in the clinical detection of active spondylolysis and to determine whether MRI is equivalent to the clinical gold standard of bone scintigraphy and CT in the radiological diagnosis of this condition.</td>
<td>MRI revealed bone stress in 40/50 pars interarticales in which it was detected by bone scintigraphy (with SPECT), indicating reduced sensitivity in detecting bone stress compared with bone scintigraphy (P=0.001). Conversely, MRI revealed 18/19 pars interarticularis fractures detected by CT, indicating concordance between imaging modalities (P=0.345). Significant difference between MRI and the combination of bone scintigraphy (with SPECT)/CT in the radiological visualization of active spondylolysis (P=0.002). Results suggest high rate of active spondylolysis in active athletes with LBP. The one-legged hyperextension test is not useful in detecting active spondylolysis and should not be relied on to exclude the diagnosis. MRI is inferior to bone scintigraphy (with SPECT)/CT. Bone scintigraphy (with SPECT) should remain the first-line investigation of active athletes with LBP followed by limited CT if bone scintigraphy is positive.</td>
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<td>41. Pneumaticos SG, Chatziioannou SN, Hipp JA, Moore WH, Esses SI. Low back pain: prediction of short-term outcome of facet joint injection with bone scintigraphy. Radiology 2006; 238(2):693-698.</td>
<td>Experimental</td>
<td>47 consecutive patients</td>
<td>Prospective randomized study to evaluate use of bone scintigraphy with SPECT for identification of patients with LBP who would benefit from facet joint injections.</td>
<td>Patients with bone scintigraphy/SPECT positive findings had improved pain score at 1 month post treatment (13/15), while fewer improved in groups without localized SPECT findings (2/16) or with clinical localization alone (5/16). Bone scintigraphy with SPECT can help identify patients with LBP who would benefit from facet joint injections.</td>
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<td>42. Even-Sapir E, Martin RH, Mitchell MJ, Iles SE, Barnes DC, Clark AJ. Assessment of painful late effects of lumbar spinal fusion with SPECT. J Nucl Med 1994; 35(3):416-422.</td>
<td>Review/other</td>
<td>33 patients, 3 independent reviewers</td>
<td>Retrospective review of planar, SPECT and other contemporaneous radiologic images of the spine and the medical records of patients with back pain after lumbar fusion surgery in order to determine the value of SPECT in the assessment of painful late effects of spinal fusion surgery.</td>
<td>Lesions in the vertebral bodies and apophyseal joints in the free motion segments adjacent to the fused segments occurred in 46% of patients after lateral fusion, in 87.5% of patients after posterior fusion and in 67% of patients after posterior and anterior fusions. No SPECT abnormalities were detected in the fused segments in patients in the late group with solid lateral fusion but were detected in 3 patients with solid posterior fusion. Lateral fusion was found to have a more stabilizing effect than posterior fusion. Results indicate that SPECT is of value in the assessment of painful late effects of fusion.</td>
<td>4</td>
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<tr>
<td>43. Holder LE, Machin JL, Asdourian PL, Links JM, Sexton CC. Planar and high-resolution SPECT bone imaging in the diagnosis of facet syndrome. J Nucl Med 1995; 36(1):37-44.</td>
<td>Observational</td>
<td>58 consecutive patients</td>
<td>To determine the appearance of potentially symptomatic facet joints on planar and high-resolution SPECT radionuclide bone imaging, relate the relative sensitivity of the two techniques and assess the predictive value in a clinical setting.</td>
<td>43 patients comprised the final study group; 7 diagnosed with facet syndrome, 5 with abnormal planar images and 7 with abnormal SPECT images. High sensitivity (100% SPECT, 71% planar), but somewhat lower specificity (71% SPECT, 76% planar). NPV was high (100% SPECT, 93% planar). Radionuclide bone imaging additionally discovered a nonfacet joint etiology for patient symptoms in 16/43 patients. Higher spatial resolution SPECT images are better accepted by referring physicians who correlate them with CT or MRI. The high NPV allows radionuclide bone imaging to be used to select appropriate patients to undergo the invasive facet injection procedure.</td>
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* See Last Page for Key

2011 Review

Davis

Page 14
<table>
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<td>44.</td>
<td>Review/other</td>
<td>37 patients had CT-SPECT fusion imaging</td>
<td>To examine the value of CT-SPECT fusion for diagnosing painful facet arthropathy.</td>
<td>CT-SPECT combines the virtues of functional and anatomical imaging, aiding the clinician in making the diagnosis of painful facet arthropathy. This modality may prove useful for the selection of patients who are candidates for posterior dynamic stabilization.</td>
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<td>45.</td>
<td>Review/other</td>
<td>1 patient</td>
<td>A report on malignant pleural mesothelioma discovered in a Tc-99m MDP bone scan as a photopenic lesion in a 64-year-old man presenting with LBP and diagnosed with FDG-PET/CT.</td>
<td>The Tc-99m MDP bone scan showed a photopenic defect occupying the left side of the T11 vertebra and implicated the existence of a tumor. Pathologic analysis of the paraspinal tumor indicated metastatic neoplastic cells, which the authors initially suspected originated from the gastrointestinal tract. The CT and MRI showed no additional information about the primary malignancy; therefore, an FDG-PET/CT study was performed, which suggested malignant pleural mesothelioma. The present case highlights both the value of a Tc-99m MDP bone scan when MPM presents, unusually, as LBP, and the importance of carefully interpreting bone scan images, especially for photopenic defects. It also indicates the usefulness of FDG-PET/CT study in malignant pleural mesothelioma in a difficult histopathological diagnosis.</td>
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<td>46.</td>
<td>Review/other</td>
<td>N/A</td>
<td>Review imaging modalities used in adults with LBP in the primary care setting.</td>
<td>MRI is likely in most cases to offer the greatest sensitivity and specificity for systemic diseases, and its performance is superior to that of radiographs and comparable with CT and radionuclide bone scans for most conditions causing neurologic compromise.</td>
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<td>47. Post MJ, Sze G, Quencer RM, Eismont FJ, Green BA, Gahbauer H. Gadolinium-enhanced MR in spinal infection. <em>J Comput Assist Tomogr</em> 1990; 14(5):721-729.</td>
<td>Review/other</td>
<td>33 patients</td>
<td>To prospectively examine plain vs contrast MRI in evaluation of spinal infection.</td>
<td>Advantages of gadolinium-enhanced MRI: provided excellent anatomical delineation of all epidural abscesses, routinely differentiating them from the adjacent compressed thecal sac even when this was not possible by noncontrast MRI; increased observer confidence in the diagnosis of disk space infection and osteomyelitis in patients with equivocal noncontrast MRI; localized those portions of paraspinal masses most likely to yield a positive percutaneous biopsy; and identified active infections from those that had responded adequately to antibiotic therapy. Contrast MRI is a valuable adjunct to noncontrast MRI when diagnosis, anatomical clarity, and/or lesion activity requires further elucidation.</td>
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* See Last Page for Key

2011 Review

Davis

Page 16
ACR Appropriateness Criteria®

Evidence Table Key

Abbreviations Key

CI = Confidence interval
CT = Computed tomography
FDG-PET = Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography
LBP = Low back pain
MDP = Methylene diophosphate
MRI = Magnetic resonance imaging
NPV = Negative predictive value
NSAIDs = Nonsteroidal anti-inflammatory drugs
PPV = Positive predictive value
SPECT = Single-photon emission tomography

Study Quality Category Definitions

- **Category 1**  The study is well-designed and accounts for common biases.
- **Category 2**  The study is moderately well-designed and accounts for most common biases.
- **Category 3**  There are important study design limitations.
- **Category 4**  The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.