

**Back Pain-Child
EVIDENCE TABLE**

| Reference | Study Type | Patients/ Events | Study Objective (Purpose of Study) | Study Results | Study Quality |
|---|------------------|---------------------|--|--|------------------|
| 1. Ramirez N, Flynn JM, Hill BW, et al. Evaluation of a systematic approach to pediatric back pain: the utility of magnetic resonance imaging. <i>J Pediatr Orthop.</i> 2015;35(1):28-32. | Observational-Dx | 261 patients | To (1) describe the prevalence of back pain seen in a pediatric orthopedic clinic; (2) evaluate the efficacy of a systematic approach dependent on MRI in the diagnosis of pediatric back pain; and (3) analyze sensitivity, specificity, positive predictive value, and NPV of various clinical signs and symptoms. | The prevalence of chief complaint of back pain was 8.6% (261/3042 patients). Of the 261 patients, 34% had an identifiable pathology following the systematic approach. In 8.8% of patients, the diagnosis was established with the history, physical examination, and plain radiographs. MRI yielded a definitive diagnosis in another 25% of patients. It is noteworthy that of the 89 patients with a confirmed pathology, 26% were identified with plain radiographs and 74% with MRI. | 3 |
| 2. Kjaer P, Wedderkopp N, Korsholm L, Leboeuf-Yde C. Prevalence and tracking of back pain from childhood to adolescence. <i>BMC Musculoskelet Disord.</i> 2011;12:98. | Review/Other-Dx | 771 children | To show the prevalence estimates of back pain, LBP, mid back pain, neck pain, and care-seeking because of back pain at 3 different ages (9, 13 and 15 years) and how the back pain reporting tracks over these age groups over 3 consecutive surveys. | Of the 771 children sampled, 62%, 57%, and 58% participated in the 3 back surveys and 34% participated in all 3. The prevalence estimates for children at the ages of 9, 13, and 15, respectively, were for back pain 33%, 28%, and 48%; for LBP 4%, 22%, and 36%; for mid back pain 20%, 13%, and 35%; and for neck pain 10%, 7%, and 15%. Seeking care for back pain increased from 6% and 8% at the 2 youngest ages to 34% at the oldest. Only 7% of the children who participated in all 3 surveys reported back pain each time and 30% of these always reported no pain. The patterns of development differed for the 3 spinal regions and between genders. Status at the previous survey predicted status at the next survey, so that those who had pain before were more likely to report pain again and vice versa. This was most pronounced for care-seeking. | 4 |

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| 3. Shymon SJ, Yaszay B, Dwek JR, Proudfoot JA, Donohue M, Hargens AR. Altered disc compression in children with idiopathic low back pain: an upright magnetic resonance imaging backpack study. <i>Spine (Phila Pa 1976)</i> . 2014;39(3):243-248. | Experimental-Dx | 15 pediatric and adolescent patients | To analyze the lumbar spine's response to backpack loads with upright MRI in children with idiopathic LBP to compare their results with previously published normal child data under the same conditions. We hypothesize that typical backpack loads will have a different effect on the lumbar spine of normal children and children with idiopathic LBP. | The cohort's mean age was 13 +/- 3 years. The 4-kg and 8-kg backpacks only compressed the L5-S1 intervertebral discs relative to upright with no load. Subjects experienced increasing pain with increasing load. Load had no effect on lumbar lordosis or lumbar coronal deformity. Compared with normal children, children with idiopathic LBP experience significantly less disc compression at T12-L1 to L4-L5, less lumbar lordosis, and more pain with increasing load. | 3 |
| 4. Bhatia NN, Chow G, Timon SJ, Watts HG. Diagnostic modalities for the evaluation of pediatric back pain: a prospective study. <i>J Pediatr Orthop</i> . 2008;28(2):230-233. | Review/Other-Dx | 73 patients | To prospectively examine the rate of diagnosis for pediatric back pain and the value of various diagnostic studies for this problem. | 57 patients (78.1%) ended with no diagnosis. Of the remaining 16, 9 were diagnosed with spondylolysis with or without spondylolisthesis. 3 other patients had abnormal laboratory values but no definitive diagnosis. Other diagnoses included Scheuermann disease (n = 2), osteoid osteoma (n = 1), and a herniated disk (n = 1). | 4 |
| 5. Feldman DS, Straight JJ, Badra MI, Mohaideen A, Madan SS. Evaluation of an algorithmic approach to pediatric back pain. <i>J Pediatr Orthop</i> . 2006;26(3):353-357. | Observational-Dx | 87 patients | To review an algorithm for the evaluation of pediatric back pain and assesses critical factors in the history and physical examination that are predictive of specific diagnoses. | 21 (24%) of 87 patients had positive radiographs and were treated for their specific diagnoses. 19 (29%) of 66 patients with negative radiographs had constant pain, night pain, radicular pain, and/or an abnormal neurological examination. 10 of these 19 patients had a specific diagnosis determined by MRI. Therefore, 31 (36%) of 87 patients had a specific diagnosis. Back pain of other 56 patients was of a nonspecific nature. No specific diagnoses were missed at latest follow-up. Specificity for determining a specific diagnosis was very high for radicular pain (100%), abnormal neurological examination (100%), and night pain (95%). Radicular pain and an abnormal neurological examination also had high positive predictive value (100%). Lumbar pain was the most sensitive (67%) and had the highest NPV (75%). | 3 |

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| 6. Miller R, Beck NA, Sampson NR, Zhu X, Flynn JM, Drummond D. Imaging modalities for low back pain in children: a review of spondylosis and undiagnosed mechanical back pain. <i>J Pediatr Orthop</i> . 2013;33(3):282-288. | Observational-Dx | 2846 patients | To determine the natural history of LBP, evaluate the value of radiographic studies in establishing a diagnosis of spondylolysis, and determine the cost and radiation effective doses associated with those studies with the associated risks radiation exposure. | A total of 2846 patients (63% female) with average age of 14.3 years were identified. A total of 2159 (76%) patients had undiagnosed mechanical LBP, 61% of that had ≤2 follow-up visits. 194 patients (7.8%) were diagnosed with spondylolysis; 119 (86%) by plain film, 56 (12.5%) by bone scans, and 17 (1.5%) by CTs. Most patients (74%) with spondylolysis had a positive plain film study. There was no significant difference between 2-view (anterior-posterior, lateral) and 4-view (anterior-posterior, lateral, right oblique, left oblique) studies in sensitivity (78% vs 72%, <i>P</i> =0.39). Advanced imaging was pursued in 90/354 (25%) patients with negative plain film studies. The sensitivity of bone scan for spondylolysis was 84% (73/88 bone scans were positive). The sensitivity of CT for spondylolysis was 90% (44/49 CTs were positive). Bone scans exposed patients to much more radiation than CTs and plain film studies. | 3 |
| 7. Khoury NJ, Hourani MH, Arabi MM, Abi-Fakher F, Haddad MC. Imaging of back pain in children and adolescents. <i>Curr Probl Diagn Radiol</i> . 2006;35(6):224-244. | Review/Other-Dx | N/A | To present the imaging findings of the wide spectrum of musculoskeletal diseases causing back pain in children and adolescents. | No results stated in abstract. | 4 |
| 8. Rodriguez DP, Poussaint TY. Imaging of back pain in children. <i>AJNR Am J Neuroradiol</i> . 2010;31(5):787-802. | Review/Other-Dx | N/A | To describe 1) the epidemiology of back pain in children, 2) the imaging workup used, and 3) the correlation of imaging findings with disease entities that may cause back pain in the pediatric patient. | No results stated in abstract. | 4 |
| 9. Sucato DJ, Micheli LJ, Estes AR, Tolo VT. Spine problems in young athletes. <i>Instr Course Lect</i> . 2012;61:499-511. | Review/Other-Dx | N/A | To provide a review on the causes of back pain to be diagnosed and possible treatments so that young athletes can quickly return to sports participation. | No results stated in abstract | 4 |

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| 10. Schlemmer E, Mitchiner JC, Brown M, Wasilevich E. Imaging during low back pain ED visits: a claims-based descriptive analysis. <i>Am J Emerg Med.</i> 2015;33(3):414-418. | Review/Other-Dx | 14,838 events | To determine the frequency and type of nonindicated imaging during LBP emergency department visits and to describe demographic and prior health care use characteristics among the nonindicated population. | Of the 14,838 total events, 51.9% (95% CI, 51.1%–52.7%) did not have indications for imaging. Patients without imaging indications were less likely to have had emergency department visits, hospital stays, LBP, lower back imaging, primary care physician visits, and back-related specialist visits in the past year compared with patients with indications. Among nonindicated patients, 30.1% (95% CI, 29.1%–31.1%) received imaging; of these, 26.2% received advanced imaging (CT or MRI). Nonindicated patients who received imaging were slightly older than those who did not receive imaging (27.6% [95% CI, 25.8%–29.4%] were ages 55-64 years vs 20.6% [95% CI, 19.6%–21.7%]) and had a higher prevalence of observation/treatment room use (7.3% [95% CI, 6.2%–8.4%] vs 1.2% [95% CI, 0.9%–1.4%]). | 4 |
| 11. Bernstein RM, Cozen H. Evaluation of back pain in children and adolescents. <i>Am Fam Physician.</i> 2007;76(11):1669-1676. | Review/Other-Dx | N/A | To evaluate back pain in children and adolescents. | No results stated in abstract. | 4 |
| 12. Haidar R, Saad S, Khoury NJ, Musharrafieh U. Practical approach to the child presenting with back pain. <i>Eur J Pediatr.</i> 2011;170(2):149-156. | Review/Other-Dx | N/A | To summarize the most commonly encountered causes of back pain in children and highlight diagnostic approaches that will ensure early diagnosis and intervention for a more favorable outcome. | No results stated in abstract | 4 |
| 13. Kempthorne JT, Pratt C, Smale EL, MacFarlane MR. Ten-year review of extradural spinal abscesses in a New Zealand tertiary referral centre. <i>J Clin Neurosci.</i> 2009;16(8):1038-1042. | Review/Other-Dx | 42 patients | To define the presentation, findings and prognosis of extradural spinal abscess in a New Zealand tertiary referral center. | Staphylococcus aureus was identified in 67% of patients. On presentation, 27/38 patients with back pain were afebrile and 2/37 patients had a normal C-reactive protein level in the first 24 hours. 10 patients were discharged with neurological dysfunction and 1 died. | 4 |

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| 14. Yee DK, Samartzis D, Wong YW, Luk KD, Cheung KM. Infective spondylitis in Southern Chinese: a descriptive and comparative study of ninety-one cases. <i>Spine (Phila Pa 1976)</i> . 2010;35(6):635-641. | Review/Other-Dx | 91 patients | To assess the prevalence, risk factors, clinical features, and prognostic outcomes associated with tuberculous spondylitis to that of pyogenic spondylitis in Southern Chinese treated at a single institution. | 91 patients were identified. Overall, tuberculous spondylitis and pyogenic spondylitis entailed 22 (24.2%) and 69 (75.8%) cases, respectively. <i>Staphylococcus aureus</i> was the most commonly isolated infective agent associated with pyogenic spondylitis. Individuals with pyogenic spondylitis were significantly much older than those with tuberculous spondylitis ($P=0.001$). Intravenous drug addiction was the most commonly noted risk factor followed by diabetes, and found to be more prevalent in pyogenic spondylitis cases. At initial presentation, white cell count and c-reactive protein levels were higher in pyogenic spondylitis cases compared with tuberculous spondylitis ($P<0.05$). The occurrence of tuberculous spondylitis cases was predominant in the thoracic region (40.9%) ($P<0.05$). Surgical intervention was performed in 54.5% of tuberculous spondylitis and in 24.6% of the pyogenic spondylitis cases ($P=0.009$). | 4 |
| 15. Altaf F, Heran MK, Wilson LF. Back pain in children and adolescents. <i>Bone Joint J</i> . 2014;96-B(6):717-723. | Review/Other-Dx | N/A | To review the important causes of back pain in children and adolescents, of which defects and stress reactions of the pars interarticularis are the most common identifiable problems. | No results stated in abstract | 4 |
| 16. Summers BN, Singh JP, Manns RA. The radiological reporting of lumbar Scheuermann's disease: an unnecessary source of confusion amongst clinicians and patients. <i>Br J Radiol</i> . 2008;81(965):383-385. | Review/Other-Dx | 50 reports | To investigate how often the diagnosis of Scheuermann's disease was made at a District General Hospital in radiological reports sent to local general practitioners; to determine the type of "Scheuermann's disease" being described; and to assess what general practitioners understood by the term "Scheuermann's disease" in the context of a specific clinical presentation. | Review of the radiographs revealed that 80% showed features of lumbar Scheuermann's disease and 20% classical Scheuermann's. A questionnaire was issued to local general practitioners that described a case history of an adult patient with typical mechanical lower back pain for whom a radiological report, describing degenerative changes in the lumbar spine, concluded that some of the features "were consistent with Scheuermann's disease". 86% of general practitioners stated that they would inform their patients that they had "Scheuermann's disease" (using that exact term), but only 51% understood the meaning of the diagnosis in the context of the case history. | 4 |

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| 17. Hospach T, Langendoerfer M, von Kalle T, Maier J, Dannecker GE. Spinal involvement in chronic recurrent multifocal osteomyelitis (CRMO) in childhood and effect of pamidronate. <i>Eur J Pediatr.</i> 2010;169(9):1105-1111. | Review/Other-Dx | 102 children and adolescents | To address the frequency and type of spinal involvement in patients with chronic recurrent multifocal osteomyelitis as well as the outcome of these patients treated with pamidronate. | Of 102 children and adolescents with chronic recurrent multifocal osteomyelitis, 27 (26%) had involvement of the spine. Vertebral deformities were seen in 14 of these 27 patients, scoliosis or kyphosis in 6. After routine whole body MRI, 19 complained of back pain, whereas 8 were asymptomatic with spinal lesions detected incidentally. A total of 72 spinal lesions were detected, thoracic vertebrae being the most commonly affected. 7 patients were treated with pamidronate; all of whom had vertebral deformities and ongoing back pain. Pain resolution was achieved within 3 months of pamidronate treatment in every case. 1 patient subsequently developed a pain amplification syndrome. Repeat MRI performed at a mean interval of 13 months revealed partial or complete resolution of vertebral hyperintensities in every patient. Improvement of vertebral height was seen in a total of 3 vertebrae in 2 patients. Severe side effects were not observed. | 4 |
| 18. Bellah RD, Summerville DA, Treves ST, Micheli LJ. Low-back pain in adolescent athletes: detection of stress injury to the pars interarticularis with SPECT. <i>Radiology.</i> 1991;180(2):509-512. | Observational-Dx | 162 patients | To compare the accuracy with which SPECT and planar bone scintigraphy aided in localizing a stress injury to the pars interarticularis, and to evaluate whether SPECT increases the sensitivity of bone scans in detecting this lesion. | Planar scintigraphy and SPECT revealed no abnormality in 91 patients (56%). All abnormalities detected on planar images were also detectable with SPECT. SPECT showed an abnormal focus of radiotracer uptake in the lumbar spine in 71 patients (44%). In 32 of these 71 patients, these findings were also evident with planar scintigraphy. In 39 of these 71 patients, use of SPECT. Correlation with contemporaneous radiographs was made in 72 cases (including CT in 10 cases). | 3 |

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| 19. 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. <i>Br J Sports Med.</i> 2006;40(11):940-946; discussion 946. | Observational-Dx | 71 subjects | To evaluate 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. | 71 subjects were recruited. 50 pars interarticulares in 39 subjects (55%) had evidence of active spondylolysis as defined by bone scintigraphy (with SPECT). Of these, 19 pars interarticulares in 14 subjects showed a fracture on CT. The one-legged hyperextension test was neither sensitive nor specific for the detection of active spondylolysis. MRI revealed bone stress in 40 of the 50 pars interarticulares 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 of the 19 pars interarticularis fractures detected by CT, indicating concordance between imaging modalities ($P=0.345$). There was a significant difference between MRI and the combination of bone scintigraphy (with SPECT)/CT in the radiological visualization of active spondylolysis ($P=0.002$). | 2 |
| 20. Sanpera I, Jr., Beguiristain-Gurpide JL. Bone scan as a screening tool in children and adolescents with back pain. <i>J Pediatr Orthop.</i> 2006;26(2):221-225. | Observational-Dx | 142 patients | To review bone scan as a screening tool in children and adolescents with back pain | The sensitivity of the bone scan was low, 0.613 (95% CI: 0.549–0.654), although it proved to be highly specific, 0.91 (95% CI: 0.83–0.95). | 3 |

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| <p>21. Auerbach JD, Ahn J, Zgonis MH, Reddy SC, Ecker ML, Flynn JM. Streamlining the evaluation of low back pain in children. <i>Clin Orthop Relat Res.</i> 2008;466(8):1971-1977.</p> | <p>Observational-Dx</p> | <p>873 consecutive patients</p> | <p>To analyze the value of information gained from clinical examination and imaging studies (plain radiography, MRI, and SPECT) in reaching a diagnosis in children who present with isolated LBP. Our tangible goals from this analysis included (1) identification of the imaging modality or combinations of modalities best able to rule out a serious diagnosis (NPV) and least likely to miss a serious diagnosis (sensitivity); (2) development of guidelines based on this identification to streamline evaluation (reduce imaging, cost, time, radiation, and sedation); and (3) contributing to a framework on which an evidence-based approach to evaluating back pain in children can be developed.</p> | <p>57 children had negative radiographs, SPECT, and MRI and no identified organic diagnosis; they were assigned to Group I, mid back pain. The diagnoses that led to assignment of patients in Group II, organic back pain, were spondylolysis (21% [21/100]), spondylolisthesis (6%), herniated nucleus pulposus (4%), and other rare causes. The examination findings common to both groups included tenderness to palpation of the lower back, hyperextension pain of the lumbar spine, and hamstring tightness. Distinguishing between Groups I and II revealed that all 3 modalities were able to discriminate between the 2 groups ($P=0.001$). MRI had an overall NPV (predicting mid back pain) of 0.79 compared with 0.75 for SPECT and 0.68 for radiographs. The overall sensitivity of MRI alone in detecting patients with Group II diagnoses was 0.65, which was superior to SPECT (0.56) and radiographs (0.38). All combinations of anteroposterior, lateral, and oblique plain film radiography with either SPECT or MRI showed the ability to distinguish between Groups I and II ($P=0.001$) with high NPV and sensitivity values. The most useful combination of imaging and physical examination findings was MRI in conjunction with radiography and hyperextension testing, NPV and sensitivity of 1.0. Combining any imaging modality alone with hyperextension pain or hamstring tightness resulted in lower NPV and sensitivity values. A stepwise analysis showed a significant association between SPECT use and time ≤ 6 weeks ($P \leq 0.001$). A SPECT scan performed within the first 6 weeks of symptom duration ($n = 6$), regardless of physical examination findings, had a NPV and sensitivity of 1.0. After 6 weeks, there was a significant dropoff in both values.</p> | <p>3</p> |

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| 22. Cohen E, Stuecker RD. Magnetic resonance imaging in diagnosis and follow-up of impending spondylolysis in children and adolescents: early treatment may prevent pars defects. <i>J Pediatr Orthop B</i> . 2005;14(2):63-67. | Review/Other-Dx | 14 children | To evaluate the role of MRI in early diagnosis of spondylolysis. | The lumbar spine was assessed by MRI in 14 children (mean age 12.4 years) with unspecific activity-related LBP for more than 3 weeks presenting with normal plain radiographs. Impending spondylolysis was diagnosed when typical signal abnormalities were confined to the pars interarticularis without signs of thinning or fragmentation. After brace treatment for 3 months, follow-up MRI was performed 3 and 6 months after treatment. MRI signals returned to normal after 3 months in 6 patients and after 6 months in 1 patient. | 4 |
| 23. Goda Y, Sakai T, Sakamaki T, Takata Y, Higashino K, Sairyō K. Analysis of MRI signal changes in the adjacent pedicle of adolescent patients with fresh lumbar spondylolysis. <i>Eur Spine J</i> . 2014;23(9):1892-1895. | Observational-Dx | 98 adolescent patients | To investigate a discrepancy between MRI and CT findings in the spinal level distribution of spondylolysis. | MRI signal changes were detected in 150 adjacent pedicles of 101 vertebrae. Of these vertebrae, MRI signal changes in only 67 (66.3%) corresponded to L5, while changes in 34 (33.7%) corresponded to L3 or L4. In our follow-up study, the bone-healing rate with no vertebral defect was 100% at L3, 97.1% at L4, and 84.4% at L5. In addition, 11/34 (32.4%) vertebrae with signal changes at L3 or L4 occurred with L5 terminal-stage spondylolysis (no MRI signal change). | 3 |
| 24. Kobayashi A, Kobayashi T, Kato K, Higuchi H, Takagishi K. Diagnosis of radiographically occult lumbar spondylolysis in young athletes by magnetic resonance imaging. <i>Am J Sports Med</i> . 2013;41(1):169-176. | Observational-Dx | 200 consecutive young athletes | To evaluate the usefulness of MRI in diagnosing active spondylolysis early and in determining the prevalence of active spondylolysis in cases where findings were not detected on plain radiography. In addition, specific clinical features to aid in the early detection of active spondylolysis were evaluated. | 97 (48.5%) patients showed evidence of active spondylolysis on MRI, findings that had been missed by plain radiography. These pars defects were organized into the following categories based on CT findings: nonlysis stage, 52; very early stage, 37; late early stage, 22; progressive stage, 10; and terminal stage, 0. No significant physical examination factors were identified that could assist in the early detection of active spondylolysis. | 3 |

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| 25. Kjaer P, Leboeuf-Yde C, Sorensen JS, Bendix T. An epidemiologic study of MRI and low back pain in 13-year-old children. <i>Spine (Phila Pa 1976)</i> . 2005;30(7):798-806. | Observational-Dx | 439 children | To describe associations between “abnormal” lumbar MRI findings and LBP in 13-year old children. | Signs of disc degeneration were noted in approximately 1/3 of the subjects. Reduced signal intensity and irregular nucleus shape in the upper 3 lumbar discs were significantly associated with LBP within the last month (OR, 2.5–3.6), whereas reduced signal intensity and disc protrusion at L5-NS1 were associated with seeking care (OR, 2.8 and 7.7, respectively). Endplate changes in relation to the L3 discs were associated with LBP month and seeking care (OR, between 9.7 and 22.2). Anterolisthesis at L5 was associated with seeking care (OR, 4.3). There were obvious differences between genders: degenerative disc changes in the upper lumbar spine were more strongly associated with LBP in boys, while disc abnormalities in the lower lumbar spine were more strongly associated with seeking care in girls. | 2 |
| 26. Ozgen S, Konya D, Toktas OZ, Dalgıncı A, Ozek MM. Lumbar disc herniation in adolescence. <i>Pediatr Neurosurg</i> . 2007;43(2):77-81. | Review/Other-Tx | 17 adolescents | To assess the radiological, clinical and surgical features and case outcomes for adolescents with lumbar disc herniation, and to compare with adult cases. | The collected histories revealed that 14 (82%) of the 17 cases involved trauma or intense sports activity. LBP was the most common complaint (15 cases, 88%). None of the 17 patients had major symptoms during follow-up, and most were engaged in intense sports or heavy work-related activities during this period. The main features of lumbar disc herniation in adolescents are different from those seen in adults. | 4 |
| 27. Garg S, Dormans JP. Tumors and tumor-like conditions of the spine in children. <i>J Am Acad Orthop Surg</i> . 2005;13(6):372-381. | Review/Other-Dx | N/A | To review tumors and tumor-like conditions of the spine in children | No results stated in abstract | 4 |
| 28. Huisman TA. Pediatric tumors of the spine. <i>Cancer Imaging</i> . 2009;9 Spec No A:S45-48. | Review/Other-Dx | N/A | To provide a review of pediatric tumors of the spine. | No results stated the abstract. | 4 |

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| 29. Dietrich A, Vaccarezza H, Vaccaro CA. Iliopsoas abscess: presentation, management, and outcomes. <i>Surg Laparosc Endosc Percutan Tech.</i> 2013;23(1):45-48. | Observational-Tx | 34 consecutive patients | To analyze presentation, treatment, and outcomes in a series of patients with diagnosis of pyogenic iliopsoas abscess. | Primary and secondary abscess occurred in 20.6% and 79.4%, respectively. The leading cause of pyogenic iliopsoas abscess was spondylodiscitis (38%) and CT was the preferred diagnostic modality (87%). Most common presentation was left unilateral abscess in 66% of patients and most frequent isolated bacteria were Staphylococcus aureus. 15 patients (44%) received antibiotics as initial treatment with an initial failure rate of 80%; 11/15 patients required a second treatment. 16 patients (47%) underwent percutaneous drainage as first line treatment with a success rate of 50%. However, success rate of percutaneous drainage, increased to 100% after 2 drainages. 3 patients were surgically drained without success (0 of 3 patients). Compared with the rest of the population, percutaneous drainage showed a lower hospital stay (25 vs 14 d, respectively, $P=0.08$) whereas surgery had a higher mortality rate (8% vs 22%, respectively, $P=0.03$). | 3 |

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| 30. Gregory PL, Batt ME, Kerslake RW, Scammell BE, Webb JF. The value of combining single photon emission computerised tomography and computerised tomography in the investigation of spondylolysis. <i>Eur Spine J.</i> 2004;13(6):503-509. | Observational-Dx | 118 patients | The aim of this study was to assess the diagnostic value of combining SPECT with reverse gantry CT in the investigation of spondylolysis. | SPECT showed increased scintigraphic uptake in 80 patients, and spondylolysis was identified on reverse gantry CT in 53. The Cohen Kappa ratio of 0.362 (95% CI: 0.198–0.526) suggests only fair agreement for the result of increased scintigraphic activity with the finding of spondylolysis on reverse gantry CT. We conclude that these investigations give mutually exclusive information, which leads to 4 diagnostic categories. When there was increased scintigraphic activity on SPECT, 58.8% (95% CI: 48.0%–69.5%) of patients had spondylolysis on reverse gantry CT. With rest from provoking activities, these lesions may heal. We interpret the findings of increased scintigraphic activity, but no spondylolysis demonstrated on reverse gantry CT as indicating a bone stress response. These also require rest from provoking activity to prevent a stress fracture developing. In this study, 84.2% (95% CI: 72.67%–95.8%) of those patients without increased activity on SPECT had no spondylolysis identified on reverse gantry CT. | 3 |
| 31. DePalma MJ, Bhargava A. Nonspondylolytic etiologies of lumbar pain in the young athlete. <i>Curr Sports Med Rep.</i> 2006;5(1):44-49. | Review/Other-Dx | N/A | To review nonspondylolytic etiologies of lumbar pain in the young athlete. | No results stated in abstract | 4 |

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| 32. Wang H, Cheng J, Xiao H, Li C, Zhou Y. Adolescent lumbar disc herniation: experience from a large minimally invasive treatment centre for lumbar degenerative disease in Chongqing, China. <i>Clin Neurol Neurosurg.</i> 2013;115(8):1415-1419. | Observational-Tx | 120 adolescent patients | To discuss the etiology, medical history, physical examination, imaging characteristics and treatment modalities relevant to this entity aiming to increase awareness among pediatricians regarding lumbar disc herniation in young children. | The present retrospective analysis was performed on 121 adolescent patients (2.6%, 121/4695 cases with lumbar disc herniation operations) with lumbar disc herniation. 113 patients (93.4%) presented with LBP with or without radiculopathy, and 12 patients (9.9%) presented with leg pain as the first symptom. Only 60 patients (49.6%) were diagnosed with lumbar disc herniation as their first outpatient diagnosis. 38 patients (31.4%) had a history of trauma before the onset of their symptoms. The most common segments were L4/5 (61, 50.4%), L5/S1 (42, 34.7%) and L4/5+L5/S1 (13, 10.7%). Disc herniation was centrolateral in 77.7% (n=94) and central in 35.5% (n=43). 80 patients were treated by microendoscopy discectomy, 25 by percutaneous endoscopic lumbar discectomy and 16 by open lumbar discectomy. The rate of operative complications was 3.8%, 4.0% and 6.3% in microendoscopy discectomy, percutaneous endoscopic lumbar discectomy and open lumbar discectomy, respectively. Through the ordinal regression analysis, we found that the patients with central disc herniation had much better outcomes than the patients with centrolateral disc herniation ($P=0.046$). | 3 |
| 33. Vendhan K, Sen D, Fisher C, Ioannou Y, Hall-Craggs MA. Inflammatory changes of the lumbar spine in children and adolescents with enthesitis-related arthritis: magnetic resonance imaging findings. <i>Arthritis Care Res (Hoboken).</i> 2014;66(1):40-46. | Observational-Dx | 79 patients | To describe and profile abnormalities of the lumbar spine in a cohort of patients with enthesitis-related arthritis as compared to a control group of adolescents with mechanical back pain. The contrast agent used was gadoterate meglumine, which was administered as an intravenous bolus at a dose of 0.2 mmoles/kg. | 1 or more abnormalities of the lumbar spine were found in 39 (67%) of 58 cases and sacroiliitis was present in 45 (78%) of the cases. Apophyseal joint synovitis was seen in 22 (38%) cases and in 1 (5%) control patient. This difference was highly significant ($P=0.004$). Inflammatory changes in the interspinous ligaments were seen in a higher percentage of cases than controls and this observation was of statistical significance ($P=0.04$). | 2 |

**Back Pain-Child
EVIDENCE TABLE**

| Reference | Study Type | Patients/ Events | Study Objective (Purpose of Study) | Study Results | Study Quality |
|--|------------------------|---------------------|---|--|------------------|
| <p>34. Joseph RN, Batty R, Raghavan A, Sinha S, Griffiths PD, Connolly DJ. Management of isolated syringomyelia in the paediatric population--a review of imaging and follow-up in a single centre. <i>Br J Neurosurg.</i> 2013;27(5):683-686.</p> | <p>Review/Other-Dx</p> | <p>39 patients</p> | <p>To assess the natural history of isolated syringomyelia in children.</p> | <p>39 patients were included with a mean age at diagnosis of 10.6 years. The average syrinx AP diameter was 3.30 mm. The rostrocaudal length of the syringes varied between 2 and 19 vertebral bodies. 27 out of 39 syringes were thoracic in origin. There were 3 and 6 syringes involving the cervicothoracic and thoracolumbar regions, respectively, with 3 involving the cervical area only. 11 out of 39 (Group I) patients were found “incidentally” during workup for adolescent idiopathic scoliosis and these were considered as a separate group. These patients did not have any significant symptoms and were discharged following their scoliosis correction surgery. Syrinx was incidental in 14 further patients (Group II). Of the 14 patients, 11 remained asymptomatic with no change in syrinx morphology throughout follow-up. Of the 14 patients, 3 were lost to follow-up. Of the 39 patients, 14 (Group III) presented with progressive back pain without any obvious clinical cause. Of the 14, 10 either improved or remained the same. Of the 14 patients, 3 underwent lumbar puncture, 1/14 having myelography. All 4/14 patients reported significant pain reduction on follow up following intervention.</p> | <p>4</p> |

**Back Pain-Child
EVIDENCE TABLE**

| Reference | Study Type | Patients/ Events | Study Objective (Purpose of Study) | Study Results | Study Quality |
|---|-----------------|---------------------------|--|---|------------------|
| 35. Lohani S, Rodriguez DP, Lidov HG, Scott RM, Proctor MR. Intracranial meningocele in the pediatric population. <i>J Neurosurg Pediatr.</i> 2013;11(6):615-622. | Review/Other-Dx | 13 pediatric patients | To categorize the clinical presentation, radiological appearance, surgical anatomy, and operative results in pediatric patients undergoing operation for intracranial meningocele. | There were 13 patients (11 boys and 2 girls) who underwent operation for intracranial meningocele. The median age was 8 years (range 5 months–16 years). The most common presenting symptom was back pain (in 5) often described as deep tail bone pain, followed by urinary incontinence (3) and constipation (2). 3 patients had evidence of associated tethered cord on MRI studies. 4 patients were asymptomatic and their diagnosis was made following imaging for other reasons; they were surgically treated because of the increasing size of the lesion or association with other congenital lesions. Most patients had symptomatic improvement after surgery. | 4 |
| 36. Lehman VT, Murphy RC, Maus TP. 99mTc-MDP SPECT/CT of the spine and sacrum at a multispecialty institution: clinical use, findings, and impact on patient management. <i>Nucl Med Commun.</i> 2013;34(11):1097-1106. | Review/Other-Dx | 212 SPECT/CT examinations | To assess the optimal clinical role and true clinical impact of SPECT/CT of the spine and sacrum. | Of the 212 SPECT/CT examinations of the spine and sacrum identified, 191 (90%) were for pain evaluation, 14 (7%) were to assess infection, and 7 (3%) were to evaluate a potential malignancy. The most common specific indication was evaluation of facet joint pain in 70/191 (37%) patients, and the most common finding was facet joint activity in 106/212 (50%) patients. Several findings were reported, although facet joint activity was the most frequent. The other findings included costovertebral joint activity, pars interarticularis defects, an osteoid osteoma, a lumbosacral pseudoarticulation, and a postoperative pseudoarthrosis. A resultant change in clinical management was documented in 168/212 (79%) patients. 92 of the 212 (44%) patients had undergone an MRI of the same region for any indication within +/-6 months. | 4 |

**Back Pain-Child
EVIDENCE TABLE**

| Reference | Study Type | Patients/ Events | Study Objective (Purpose of Study) | Study Results | Study Quality |
|--|------------------|--|--|--|------------------|
| 37. Borg B, Modic MT, Obuchowski N, Cheah G. Pedicle marrow signal hyperintensity on short tau inversion recovery- and t2-weighted images: prevalence and relationship to clinical symptoms. <i>AJNR Am J Neuroradiol.</i> 2011;32(9):1624-1631. | Review/Other-Dx | 446 patients, both prospective and retrospective | To assess type 1 pedicle marrow signal intensity changes and their behavior within the pedicle are associated with clinical symptoms and may be similar to and behave like type 1 pedicle marrow signal intensity changes in the vertebral body. | The prevalence of pedicle marrow hyperintensity on T2 and short tau inversion recovery weighted sequences was 1.7%. Associated morphologic abnormalities were pars interarticularis and pedicle fractures and degenerative facets. In the longitudinal study, pedicle marrow signal hyperintensity on T2 and short tau inversion recovery weighted images resolved in 17 patients and persisted in 5 patients. The extent, intensity, and resolution of signal intensity changes significantly related to the degree of functional limitation ($P=.01$). | 4 |
| 38. Kim HJ, Green DW. Spondylolysis in the adolescent athlete. <i>Curr Opin Pediatr.</i> 2011;23(1):68-72. | Review/Other-Dx | N/A | To review the typical presentation of spondylolysis in the adolescent with specific focus on the adolescent athlete. | The optimal algorithm for diagnostic imaging is controversial. SPECT can provide good sensitivity but poor specificity for spondylolysis. CT can be useful as a follow-up exam to visualize the bony anatomy and osseous healing but has the concern of high radiation exposure. MRI may be a useful tool for diagnosis and follow-up examination, which may have significant advantages over traditional imaging techniques. Brace use is controversial and most likely functions as an adjunct for limiting motion to promote activity restrictions. | 4 |
| 39. Bennett DL, Nassar L, DeLano MC. Lumbar spine MRI in the elite-level female gymnast with low back pain. <i>Skeletal Radiol.</i> 2006;35(7):503-509. | Observational-Dx | 19 Olympic-Level female gymnasts | To assess that MRI will demonstrate the same types of abnormalities in both the symptomatic and asymptomatic gymnasts. | Anterior ring apophyseal injuries (9/19) and degenerative disk disease (12/19) were common. Spondylolysis (3/19) and spondylolisthesis (3/19) were found. Focal bone-marrow edema was found in both L3 pedicles in 1 gymnast. History and physical exam revealed 4 gymnasts with current LBP at the time of imaging. There were findings confined to those athletes with current LBP: spondylolisthesis, spondylolysis, bilateral pedicle bone-marrow edema, and muscle strain. | 1 |

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EVIDENCE TABLE**

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|--|------------------|--------------------------------------|---|---|------------------|
| 40. Sairyo K, Sakai T, Amari R, Yasui N. Causes of radiculopathy in young athletes with spondylolysis. <i>Am J Sports Med.</i> 2010;38(2):357-362. | Review/Other-Dx | 10 patients | To assess the causes of radiculopathy in young athletes with spondylolysis | The pathomechanism was classified into nonspondylolytic radiculopathy (3 cases) and spondylolytic radiculopathy (7 cases). In the nonspondylolytic group, 1 patient had a juxta-facet cyst at L4-5 and 2 patients had a herniated nucleus pulposus. In the other group, spondylolytic-related factors caused radiculopathy, and spondylolysis was in the early or progressive stage in all 7 patients. Radiologic findings indicated that radiculopathy was caused by extraosseous hematoma or edema in the vicinity of the fracture site. The radiculopathy disappeared within a month of nonoperative management, and radiologic abnormalities disappeared 3 to 6 months later. | 4 |
| 41. Fadell MF, Gralla J, Bercha I, et al. CT outperforms radiographs at a comparable radiation dose in the assessment for spondylolysis. <i>Pediatr Radiol.</i> 2015;45(7):1026-1030. | Observational-Dx | 62 patients | To provide a definitive diagnosis of fractures of the pars interarticularis at comparable or lower radiation dose than commonly performed lumbar spine radiographs. | CT provided a significantly higher level of agreement among raters than radiographs ($P<0.001$). The overall Kappa for rater agreement with radiographs was 0.24, 0.34 and 0.40 for 2, 3 or 4 views, respectively, and 0.88 with CT. | 3 |
| 42. Yang J, Servaes S, Edwards K, Zhuang H. Prevalence of stress reaction in the pars interarticularis in pediatric patients with new-onset lower back pain. <i>Clin Nucl Med.</i> 2013;38(2):110-114. | Observational-Dx | 63 consecutive pediatric patients | To determine the prevalence of stress reaction in pars interarticularis in pediatric patients presenting new-onset back pain using both bone SPECT and CT. | Among the cohort of 63 patients who had both bone SPECT and thin-slice CT of the lumbar spine, there was a total of 56 positive SPECT results indicating stress injuries in the pars interarticularis. Spondylolysis was shown on both bone SPECT and thin-slice CT in 45 patients. In 11 patients, stress reaction was shown. In 7 patients, no abnormality was detected by either SPECT or thin-slice CT. | 3 |
| 43. Spencer HT, Sokol LO, Glotzbecker MP, et al. Detection of pars injury by SPECT in patients younger than age 10 with low back pain. <i>J Pediatr Orthop.</i> 2013;33(4):383-388. | Observational-Dx | 107 consecutive skeletal SPECT scans | To detect pars injury by SPECT in patients younger than age 10 with LBP | Of the 72 SPECT studies, 35 (49%) identified a focal area in the spine of abnormal increased uptake, with 17 in the region of the pars interarticularis. With additional imaging, 1 case was demonstrated not to be a pars injury (CT showed a transverse process fracture) and 2 patients with negative SPECT scans were shown to have pars injuries that SPECT scan had not detected, for a total of 18 pars injuries (25%) in this cohort. Reported participation in gymnastics or football was related to pars injury (OR 4.3, $P=0.04$). | 3 |

**Back Pain-Child
EVIDENCE TABLE**

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|---|-----------------|-----------------------|---|---|------------------|
| 44. Takemitsu M, El Rassi G, Woratanarat P, Shah SA. Low back pain in pediatric athletes with unilateral tracer uptake at the pars interarticularis on single photon emission computed tomography. <i>Spine (Phila Pa 1976)</i> . 2006;31(8):909-914. | Review/Other-Dx | 22 pediatric athletes | To study the clinical characteristics and outcome of pediatric athletes with LBP and unilateral tracer uptake on SPECT at the pars interarticularis but no defect on radiographs. | The average age was 12.3 +/- 2.5 years. The male-to-female ratio was 1.2:1. The average duration of symptoms was 21 +/- 23 weeks. 19 (86%) had increased uptake at L5. 6 (27%) had spina bifida occulta and 8 (36%) had scoliosis. 18 (82%) patients showed an excellent outcome. The patients who presented with a longer history of symptoms or a concomitant spina bifida occulta had an increased risk of having occasional aching with vigorous activity when compared with the patients who did not ($P<0.05$). | 4 |

Evidence Table Key

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.
- M = Meta-analysis

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

CI = Confidence interval

CT = Computed tomography

LBP=Low back pain

MRI = Magnetic resonance imaging

NPV = Negative predictive value

OR = Odds ratio

SPECT = Single-photon-emission computed tomography