Bone Infection

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HIGHLIGHTS –

- Classic MRI findings of pyogenic spondylodiscitis include: 1.) disc T2-hyperintensity, loss of the normal T2 hypointense intranuclear cleft, enhancement and disc space loss; 2.) adjacent endplate destruction and vertebral body T1-hypointensity, T2-hyperintensity and enhancement; 3.) paraspinal ill-defined inflammatory signal changes, swelling and/or abscess; and 4.) epidural enhancement, venous distension, phlegmon and/or abscess.
- Atypical MRI findings for pyogenic infection include: 1.) lack of expected signal abnormalities and endplate erosions in early stages of infection; 2.) involvement of only one vertebral body; 3.) involvement of one body and disc; 4.) involvement of two adjacent bodies without the intervening disc; and 4.) solitary or multiple discrete, enhancing osseous lesions without abnormal disc signal.
- Classic MRI findings of tuberculous infection are: 1.) similar to pyogenic spondylodiscitis; 2.) less severe disc space involvement; 3.) large paraspinal abscesses with smooth walls, with or without calcifications; and 4.) craniocaudal subligamenous spread of disease.
- Atypical MRI findings of tuberculous infection include: 1.) no disc involvement; 2.) multilevel involvement with contiguous or skip lesions; 3.) vertebra plana; 4.) posterior element involvement; and 5.) panvertebral involvement.

TARGET AUDIENCE– Musculoskeletal and neuroradiologists, general radiologists, radiology residents and fellows

OUTCOME/OBJECTIVES

1. To review the classic and atypical MR imaging features of pyogenic spondylodiscitis
2. To review the classic and atypical MR imaging features of tuberculous spondylodiscitis

PURPOSE – To delineate the classic and atypical MR imaging features of pyogenic and tuberculous spine infection in order to increase the accuracy of diagnosis, guide prompt image-guided biopsy and treatment.

DISCUSSION

Pyogenic Infection

Pyogenic infection of the spine may involve the osseous spine, intervertebral discs, ligaments and/or the extradural spine. Spondylodiscitis is most commonly caused by hematogeneous spread of remote infection (ie. urinary tract, gastrointestinal or dental infection) via an arterial route or, less commonly, the paravertebral venous plexus. Direct inoculation from spinal surgery or injections, and contiguous spread of infection from adjacent infection are less common mechanisms of involvement.[1-4] The most common isolated organism from pyogenic spondylodiscitis is *Staphylococcus aureus*, followed by other staphylococci, streptococci and enterobacteria.[5-9] *Pseudomonas* can be isolated among intravenous drug abusers, *Salmonella* in sickle cell patients, and *Haemophilus influenza* in patients with meningitis.[6] Patients at increased risk for pyogenic infection are men between the ages of 50 and 70 years old, who are diabetic, in renal failure, cirrhotic or have other causes of immunosuppression.[1] Clinical findings include focal back pain, spasm, tenderness, limited

range of motion, neurological deficits, weights loss, malaise, elevate erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), and leukocytosis.[1,6.]

Imaging of patients with suspected spine infection begins with radiographs, but they typically are revealing until several weeks after the onset of spondylodisciitis **(Fig. 1A)**.[10] Positive findings include endplate irregularity or destruction, loss of disc space height, paraspinal soft tissue fullness and/or decreased conspicuity of soft tissue planes.[1,11] Magnetic resonance imaging (MRI) without and with gadolinium enhancement is a much more sensitive imaging tool and is highly indicated in patients with suspected pyogenic infection.[10] **Classic MRI findings** of pyogenic spondylodiscitis include: 1.) intervertebral disc T2-hyperintensity, loss of the normal T2 hypointense intranuclear cleft, enhancement and associated disc space loss; 2.) adjacent endplate destruction and vertebral body T1-hypointensity, T2-hyperintensity and enhancement; 3.) paraspinal ill-defined inflammation, swelling and/or abscess; and 4.) epidural enhancement, venous distension, phlegmon and/or abscess.[1,5,6,12,13.] Overall, the most sensitive findings for pyogenic infection include paraspinal or epidural inflammation, vertebral body T1 hypointensity, disc space T2 hyperintensity and enhancement **(Figs. 1B and C)**.[1] MRI can clearly direct the level of image-guided biopsy **(Fig. 1D). Atypical MRI findings** for pyogenic infection include: 1.) lack of expected signal abnormalities and endplate erosions in early stages of infection; 2.) involvement of only one vertebral body; 3.) involvement of a single body and disc; 4.) involvement of two adjacent bodies without the intervening disc; and 4.) solitary or multiple enhancing osseous lesions without abnormal disc signal.[1]

Pyogenic infection occasionally may be confused with degenerative disc disease, neuropathic changes, dialysis-related spondyloarthropathy, and tumors such as chordoma and myeloma.[1] Severely degenerative discs may be T2-hyperintense, display low signal from vacuum phenomenon, but will not enhance. Associated degenerative Modic type I endplate changes typically will be T2-hypointense (unlike hyperintense infected endplates), most pronounced laterally or at the point of maximal biomechanical stress, and the endplates will not be destroyed. Furthermore, paraspinal and spidural soft tissue inflammation and abscess are absent with degenerative disc disease. Next, neuropathic spine changes include vacuum disc phenomenon, osseous debris, disorganization with spondylolithesis or dislocation, and diffuse vertebral body T2-hyperintensity, and rim enhancement of the disc.[1,14]

Fig 1A

Fig 1B

Fig 1C

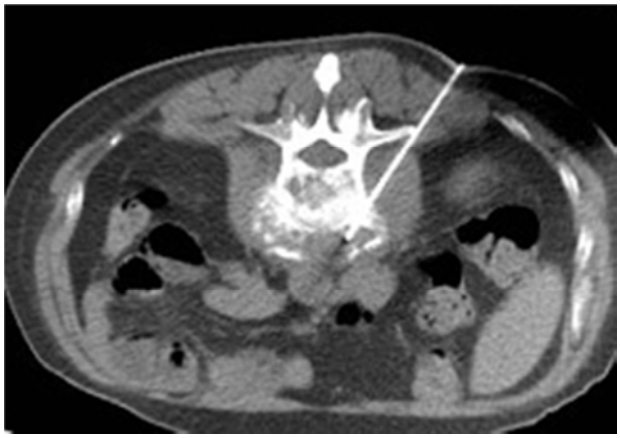

Fig 1D

Figure 1. Pyogenic spondylodiscitis in a 60-year-old man with 2 month history of back pain, fever, elevated peripheral white blood cell count, C-reactive protein and erythrocyte sedimentation rate. A.) Lateral lumbar spine radiograph shows mild spondylosis, with preservation of endplate conspicuity and disc space height. B.) Lateral T1-weighted sagittal image obtained 7 weeks later demonstrates diffusely hypointense signal throughout the L2 and L3 vertebral bodies (asterisks), endplate destruction and abnormal paraspinal soft tissue (arrowheads). C.) T1-weighted enhanced sagittall image shows marked vertebral body enhancement (asterisks), irregular endplate destruction, disc space narrowing, abnormal paraspinal soft tissue enhancement extending into the epidural region (arrow) and narrowing the central canal. D.) CT-guided biopsy from a paraspinal approach demonstrates needle placement within the L2-3 disc space and destroyed L2 anterior inferior endplate.

Tuberculous Infection

Tuberculous infection of the spine is a world-wide problem that has an increased incidence in patients in the developing world and indigent regions of the developed world, intravenous drug abusers, and immunocompromised patients including patients with human immunodeficiency virus (HIV). MRI is useful in delineating the extent of osseous and soft tissue tuberculous infection of the spine. Tuberculous spondylitis constitutes 2-4% of all cases of osteomyelitis, is more common in men, most often involves the thoracic spine and thoracolumbar junction.[1,15]

Tuberculous infection of the spine is manifested most commonly as spondylodiscitis, with a minority of cases presenting with solitary vertebral body involvement, multifocal skip lesions, and isolated posterior element involvement **(Fig. 2A)**.[1,13,15-18] **Classic MRI findings** of tuberculous infection are: 1.) similar to pyogenic spondylodiscitis; 2.) less severe disc space involvement; 3.) large paraspinal abscesses with smooth walls, with or without calcifications; and 4.) craniocaudal subligamenous spread of disease **(Figs. 2B-D)**.[1,13,15-18] Bone marrow edema is the earliest sign of infection on MRI, evidenced by mild hyperintense T2-weighted signal within the involved marrow.[15] In the acute phase, the marrow will be hypointense on T1-weighted images, with loss of conspicuity of the endplates, and hyperintense discs and vertebral bodies on T2-weighted images. Anterior vertebral scalloping and relative preservation of the disc space height is relatively common, and tuberculous paravertebral abscesses are usually larger than those caused by pyogenic infection. Evaluation for cord compression by epidural masses is critical. The intervertebral disc may be homogeneously T2-hyperintense with loss of the intranuclear cleft, homogeneous or heterogeneous disc enhancement, or merely T1-hypointense disc with decreased height.[15] **Atypical MRI findings** of tuberculous infection include: 1.) lack of involvement of the discs; 2.) multilevel involvement with contiguous or skip lesions; 3.) vertebra plana; 4.) posterior element involvement; and 5.) panvertebral involvement.[1,15-17]

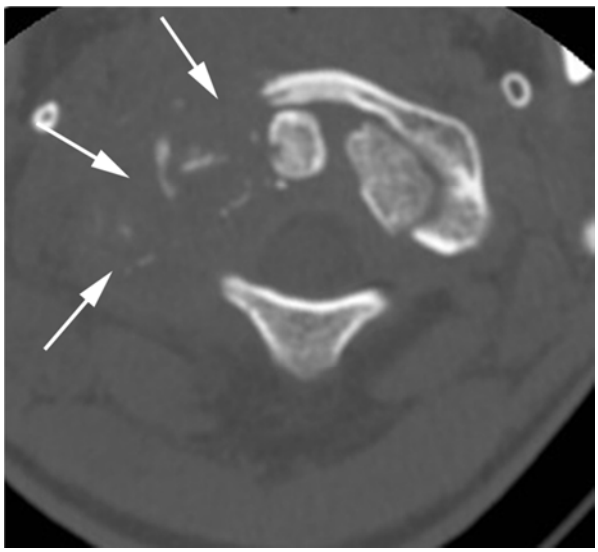

Fig 2A

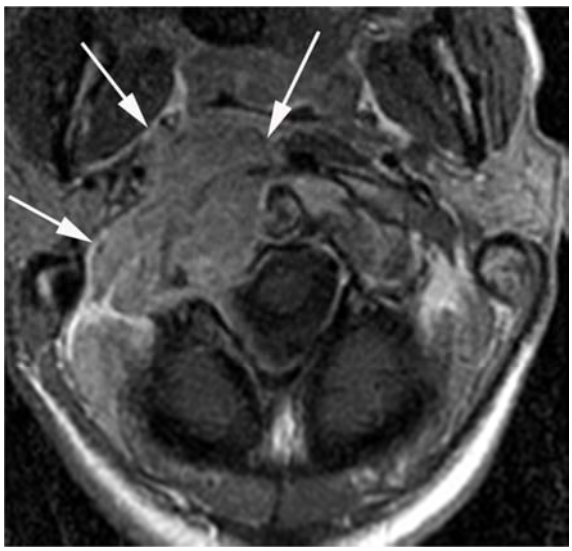

Fig 2B

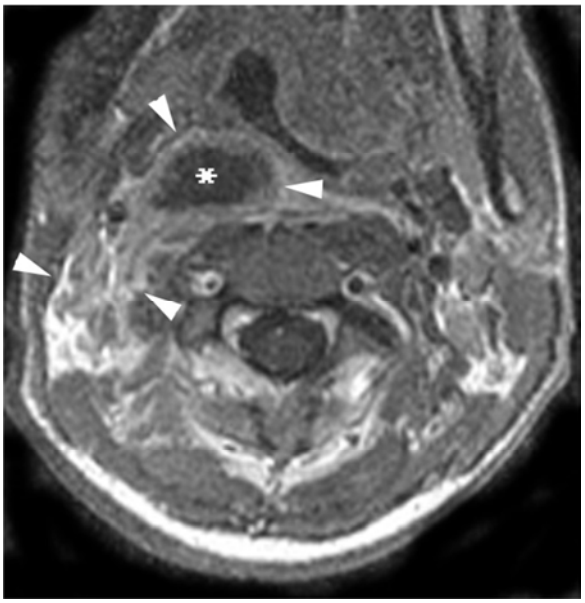

Fig 2C

Fig 2D

Figure 2. Tuberculous spondylitis, with skull base involvement and paravertebral abscess in a 25-year-old inmate with developing neck pain and disorientation. A.) Axial computed tomography through the craniocervical junction demonstrates destruction of the right aspect of C1 (arrows), right occipital condyle and small portion of the right side of the dens. B.) Axial enhanced T1-weighted image delineates an enhancing mass (arrows) centered on the destroyed right lateral mass of C1, with extension into the right lateral epidural, retropharyngeal and parapharyngeal spaces. The mass also infiltrates the right occipital condyle and small portion of the dens. C.) Axial enhanced T1-weighted image obtained more inferiorly demonstrates the thin-walled abscess (asterisk) within the large enhancing mass (arrowheads). D.) Sagittal enhanced T1-weighted image shows craniocaudal migration from the skull base to the level of C4. The enhancing abnormality (arrows) involves the clivus, dens, and C1. Epidural extension markedly narrows the central canal. (asterisk = abscess). Emergent surgical debridement was performed and cultures grew *Mycobacterium tuberculosis*.

Brucella and Fungal Infection

Brucella and fungal infections are less common than pyogenic and tuberculous spondylodiscitis, and may be difficult to differentiate from these entities on MR imaging. Brucellosis is endemic in rural Saudi Arabia and the Mediterranean region, and often found in patients ingesting raw meat or unpasteurized dairy products.[1,19] Although there are some overlapping imaging features between brucellosis and tuberculosis, brucellosis is: 1.) more common in the lumbar and lumbosacral spine; 2.) may be less aggressive; 3.) vertebral bodies are relatively preserved; 4.) posterior elements are typically spared; 5.) paraspinal involvement is relatively mild and abscesses are uncommon; and 6.) multilevel involvement is rare.[1]

Fungal spine infections are uncommon, but are most common in patients with diabetes, are otherwise immunocompromised, or have received contaminated steroid injections.[20] *Candida* and *Aspergillus* are more common infectious organisms of the spine, and MR imaging features include preservation of the intranuclear cleft and absent disc T2-hyperintensity.[21] Classic imaging features of aspergillosis include: 1.) multilevel vertebral involvement with skip lesions or subligamentous spread; 2.) serrated appearance of the endplates; and 3.) subchondral T2 hypointense signal.[22]

CONCLUSION– There are multiple MR imaging features which increase the likelihood of diagnosing pyogenic and tuberculous spine infection, guide prompt image-guided biopsy and treatment.

REFERENCES

1. Diehn FE. Imaging of spine infection. Radiol Clin North Am. 2012; 50(4):777-98.
2. Pobiel RS, Schellhas KP, Pollei SR, Johnson BA, Golden MJ, Eklund JA. Diskography: infectious complications from a series of 12,634 cases. AJNR Am J Neuroradiol. 2006; 27(9):1930-2.
3. Radcliff KE, Morrison WB, Kepler C, et al. Distinguishing pseudomeningocele, epidural hematoma, and postoperative infection on postoperative MRI. J Spinal Disord Tech. 2013. [Epub ahead of print]
4. Rey-Jouvin C, Sellam J, Chafai N, Yazid L, Miquel A, Berenbaum F. Clinical image: Spondylodiscitis due to a fistula between L5-S1 disc and colon. Joint Bone Spine. 2013; 80(1):100-1.
5. Sans N, Faruch M, Lapègue F, Ponsot A, Chiavassa H, Railhac JJ. Infections of the spinal column--spondylodiscitis. Diagn Interv Imaging. 2012; 93(6):520-9
6. Go JL, Rothman S, Prosper A, Silbergleit R, Lerner A. Spine infections. Neuroimaging Clin N Am. 2012; 22(4):755-72
7. Michel SC, Pfirrmann CW, Boos N, Hodler J.CT-guided core biopsy of subchondral bone and intervertebral space in suspected spondylodiskitis. AJR Am J Roentgenol. 2006; 186(4):977-80.
8. Kim BJ, Lee JW, Kim SJ, Lee GY, Kang HS. Diagnostic yield of fluoroscopy-guided biopsy for infectious spondylitis. AJNR Am J Neuroradiol. 2013; 34(1):233-8.
9. Wattamwar AS, Ortiz AO Use of a percutaneous diskectomy device to facilitate the diagnosis of infectious spondylitis. AJNR Am J Neuroradiol. 2010; 31(6):1157-8.
10. Davis PC, Wippold FJ 2nd, Brunberg JA, et al. ACR Appropriateness Criteria on low back pain. J Am Coll Radiol. 2009; 6(6):401-7.
11. Chandrasenan J, Klezl Z, Bommireddy R, Calthorpe D. Spondylodiscitis in children: A retrospective series. J Bone Joint Surg Br. 2011; 93(8):1122-5.

12. Eastwood JD, Vollmer RT, Provenzale JM. Diffusion-weighted imaging in a patient with vertebral and epidural abscesses. AJNR Am J Neuroradiol. 2002; 23(3):496-8.
13. Jung NY, Jee WH, Ha KY, Park CK, Byun JY. Discrimination of tuberculous spondylitis from pyogenic spondylitis on MRI.AJR Am J Roentgenol. 2004; 182(6):1405-10.
14. Wagner SC, Schweitzer ME, Morrison WB et al. Can imaging findings help differentiate spinal neuropathic arthropathy from disc space infection? Initial experience. Radiology. 2000; 214:693-9.
15. Patkar D, Narang J, Yanamandala R, Lawande M, Shah GV Central nervous system tuberculosis: pathophysiology and imaging findings. Neuroimaging Clin N Am. 2012; 22(4):677-705.
16. Sureka J, Samuel S, Keshava SN, Venkatesh K, Sundararaj GD. MRI in patients with tuberculous spondylitis presenting as vertebra plana: A retrospective analysis and review of literature. Clin Radiol. 2013; 68(1):e36-42.
17. Arora S, Sabat D, Maini L, Sural S, Kumar V, Gautam VK, Gupta A, Dhal A. Isolated involvement of the posterior elements in spinal tuberculosis: a review of twenty-four cases. J Bone Joint Surg Am. 2012; 94(20):e151.
18. Shikhare SN, Singh DR, Shimpi TR, Peh WC. Tuberculous osteomyelitis and spondylodiscitis. Semin Musculoskelet Radiol. 2011; 15(5):446-58.
19. Al-Sous MW, Bohlega S, Al-Kawi MZ, Alwatban J, McLean DR. Neurobrucellosis: Clinical and neuroimaging correlation. AJNR Am J Neuroradiol. 2004; 25(3):395-401.
20. Saigal G, Donovan Post MJ, Kozic D. Thoracic intradural aspergillus abscess formation following epidural steroid injection. AJNR Am J Neuroradiol. 2004; 25(4):642-4.
21. Williams RL, Fukui MB, Meltzer CC, Swarnkar A, Johnson DW, Welch W. Fungal spinal osteomyelitis in the immunocompromised patient: MR findings in three cases. AJNR Am J Neuroradiol. 1999; 20(3):381-5.
22. Kwon JW, Hong SH, Choi SH, et al. MRI findings of aspergillus spondylitis. AJR Am J Roentgenol. 2011; 197:W919-23.