Original Article

3-Tesla Magnetic Resonance Imaging evaluation of intraspinal extramedullary nonosseous neoplastic lesions with their postsurgical and histopathological correlation

Neeraj Prajapati, S K Rastogi, Yogendra Kumar, Abhinav Pandit, Nisma Wahed, Navreet Singh

Department of Radiodiagnosis, SRMS Institute of Medical Sciences, Bareilly, Uttar Pradesh, India

Abstract

Aims: This study aimed to evaluate the diagnostic ability of 3-Tesla magnetic resonance imaging (MRI) in detection and characterization of intraspinal extramedullary nonosseous neoplastic lesions and their histopathological correlation.

Settings and Design: It was a prospective study involving fifty patients who presented with low backache and lower limb weakness with MRI findings suggestive of a neoplastic extramedullary intraspinal lesion.

Patients and Methods: A 3-Tesla 16-channel MRI scanner was used for imaging. Multiplanar imaging was done using T1, T2, short-tau inversion recovery sequences and T1 fat-saturated sequences. All patients then underwent postgadolinium MRI. The findings of MRI were then reviewed. An analysis of correlation between MRI findings and surgical and histopathological findings was done.

Results: Out of the fifty patients evaluated, intradural lesions were noted in forty patients and extradural lesions in ten patients. Schwannoma was the most common tumor, followed by meningioma in the intradural category. Two rare cases of intradural lipoma and malignant peripheral nerve sheath tumors were also detected. In extradural category, metastasis was the most common lesion along with two rare lesions of epidural meningioma and leukemia-associated granulocytic sarcoma.

Conclusions: MRI is an indispensable tool in the evaluation of spinal neoplasms. Its multiplanar capability, high-quality soft-tissue resolution, and depiction of various anatomic landmarks help the neurosurgeon to make a road map for the surgery. In most of the cases, MRI can give information regarding the histopathology of the lesion. However, in some cases, differential diagnosis needs to be included, especially in cases of extradural meningiomas and malignant peripheral nerve sheath tumors, because of their rare incidence.

Keywords: 3-Tesla magnetic resonance imaging, extradural, intradural, spinal neoplasm

Address for correspondence: Dr. S K Rastogi, F 132 SRMS IMS Campus Bareilly, Uttar Pradesh, India.
E-mail: drneerajprajapati@rediffmail.com

INTRODUCTION

The two broad categories in which lesions affecting spinal cord are classified include extradural and intradural. The intradural lesions may be intramedullary or extramedullary. Spinal tumors account for only approximately 5%–15% of the nervous system neoplasms.[1,2] Intradural extramedullary (IDEM) spinal cord tumors constitute approximately two-thirds of these tumors.[2,3] This article focuses on extradural and IDEM neoplasms. IDEM tumors are characterized by their location within the thecal

Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/wajr.wajr_25_17

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Prajapati N, Rastogi SK, Kumar Y, Pandit A, Wahed N, Singh N. 3-Tesla magnetic resonance imaging evaluation of intraspinal extramedullary nonosseous neoplastic lesions with their postsurgical and histopathological correlation. West Afr J Radiol 2018;25:57-64.

sac, causing displacement rather than expansion of the spinal cord. Further, the tumor is separated from the cord parenchyma by a thin rim of cerebrospinal fluid (CSF).[4]

High soft-tissue contrast favors magnetic resonance imaging (MRI) as the imaging modality of choice for assessing the spinal cord. In cases with suspected spinal tumors, the standard approach should be the use of gadolinium-based contrast agents, which results in enhancement in the spinal neoplasms. This helps in differentiating tumor from other differential diagnosis such as cord edema and reactive cysts. In addition, it helps the surgeon to plan the surgery, limiting the size of laminectomy to the tumor.[4] Imaging at a 3-Tesla MRI machine gives better image resolution along with faster scan time. It also helps in utilizing the newer imaging techniques such as diffusion tensor imaging, MR neurography, and perfusion imaging.

PATIENTS AND METHODS

The present study was a prospective study of fifty patients conducted between June 2013 and June 2016 after obtaining approval from the institutional ethical committee. An informed written consent was obtained for participation in the study. Demographic characteristics, clinical presentation, and MRI findings of each patient were noted. On the basis of presenting symptoms (radiculopathy and myelopathy) and radiologic investigations, surgical intervention was done with removal of extramedullary spinal tumors. Specimens obtained were subjected to detailed histopathological analysis. Patients' records were carefully reviewed, and a correlation between histopathological findings and outcome following the surgery was done.

MRI was performed using 3-Tesla Siemens MAGNETOM Verio 16-channel scanner using standard coil for the acquisition of images. As per request of the referring doctor, MRI of the spine was done along with a screening of the whole spine. Multi-slice multi-echo sequences with a slice thickness = 3 mm, inter-slice gap = 1 mm, field of view = 300 mm, matrix = 240 × 320 with T1-weighted image (T1WI), T2-weighted image (T2WI), short-tau inversion recovery (STIR), T1 fat–saturated, and postcontrast T1WI fat-saturated sequences were used to obtain sagittal images. T1, T2, and T1 fat-saturated postcontrast sequences and STIR and T1WI fat-saturated postcontrast sequences were used to obtain axial images and coronal images, respectively. Pulse sequence of TR/TE = 500/10 msec was used for T1WIs and TR/TE = 3000/100 msec for T2WIs. A dose of 0.1 mmol/kg body weight of contrast (Gadolinium–DTPA) was given to all the patients.

RESULTS

The study included a total of fifty patients: 24 females and 26 males, with age ranging from 20 to 65 years. Majority of patients presented with low back ache and gradually progressing weakness in the lower limbs. The histopathological results were correlated in all the patients. The histopathology was consistent with the MRI diagnosis in 48 cases except two cases, in whom there was no correlation with the MRI findings. These two exceptions were cases of epidural meningioma and MRI differential diagnosis of nerve sheath tumor or lymphoma.

There were forty (80%) cases with intradural and ten (20%) cases with extradural pathology. The intradural lesions comprised 18 schwannomas, ten meningiomas, six arachnoid cysts, and two cases, each of malignant peripheral nerve sheath tumors, lipoma and neurofibroma, respectively [Table 1]. The extradural lesions comprised six metastatic lesions and two cases, each of acute myeloid leukemia and meningioma, respectively [Table 2].

DISCUSSION

Broad categories in which spinal lesions are classified include extradural and intradural. Extradural lesions are characterized by their location outside the surrounding dural sac and a frequent association with lesions of the intervertebral disc or the spinal column. On the contrary, intradural lesions are located within the dural sac and are further subdivided into intradural intramedullary or IDEM lesions. Intradural intramedullary lesions are located within the substance of the cord, whereas IDEM

Table 1: Types and numbers of various intradural lesions seen in the study

Type of intradural lesions	*n*
Schwannomas	18
Meningiomas	10
Arachnoid cyst	6
Neurofibroma	2
Lipoma	2
MPNST	2

MPNST – Malignant peripheral nerve sheath tumor

Table 2: Types and numbers of various extradural lesions seen in the study

Type of extradural lesions	*n*
Metastasis	6
Meningiomas	2
Acute leukemia	2

lesions are located outside the spinal cord but within the dural sac.[5]

Schwannoma

Schwannoma, also known as neurinoma or neurilemmoma, is a tumor arising from the support cells of the nerve sheath. It constitutes the most common tumor accounting for 25% of all IDEM spinal tumors in adults.[6] The disease affects both sexes equally with a peak incidence in fourth to sixth decades of life. Most of the cases are sporadic, though linkage with inherited tumor syndromes such as neurofibromatosis (NF)-2, schwannomatosis, and Carney complex is known. Features of progressive myelopathy and radiculopathy are the most common presenting symptoms.[7] About 15% of schwannomas present as transforaminal, "dumbbell" masses. However, the size of the tumor can vary from a small intradural mass to a large intraspinal or paravertebral mass (giant schwannoma) extending more than two vertebral segments. Cystic degeneration is very common and seen in 40% of cases whereas calcification and hemorrhage are rare and noted in just 10% of the cases. The intraspinal or transforaminal lesions are associated with bone remodeling. Spinal cord compression may hamper the blood flow, further leading to myelomalacia or edema.[8]

These lesions were primarily isointense to the spinal cord on T1WIs, hyperintense to the cord on long TR images, and demonstrated intense postcontrast enhancement [Figure 1]. The imaging finding varied depending on cases having cystic degeneration or lesions with the presence of hemorrhage and fatty degeneration. The cystic degeneration appeared as hypointense on T1WIs, hyperintense on T2WIs, and relative nonenhancement on postcontrast images [Figure 2].



Figure 1: (a) T1 sagittal image demonstrating a dumbbell-shaped isointense intradural mass (b) T2 sagittal lesion appearing iso to hyperintense (c) T2 axial confirming intradural location (d) Postcontrast T1 fat-saturated sagittal demonstrating avid homogeneous postcontrast enhancement. Histopathology reveals schwannoma

Meningioma

The second most common tumor having IDEM location is meningioma accounting for approximately 25% of all spinal tumors. Regional distribution of spinal meningiomas is as follows: 80% thoracic, 15% cervical, 3% lumbosacral, and 2% foramen magnum. Most intradural spinal tumors are benign, having good resectability and excellent prognosis after surgery.[9-13]

Meningiomas have a peak occurrence in the fifth to sixth decades of life, with a strong female predilection (80%).[14,15] Approximately 90% of spinal meningiomas are located in intradural compartment, about 5% in extradural, and the remaining 5% encroaching both intradural and extradural compartments. Patients mostly present with symptoms of local or radicular pain, weakness of the limbs, and paresthesia.[14]

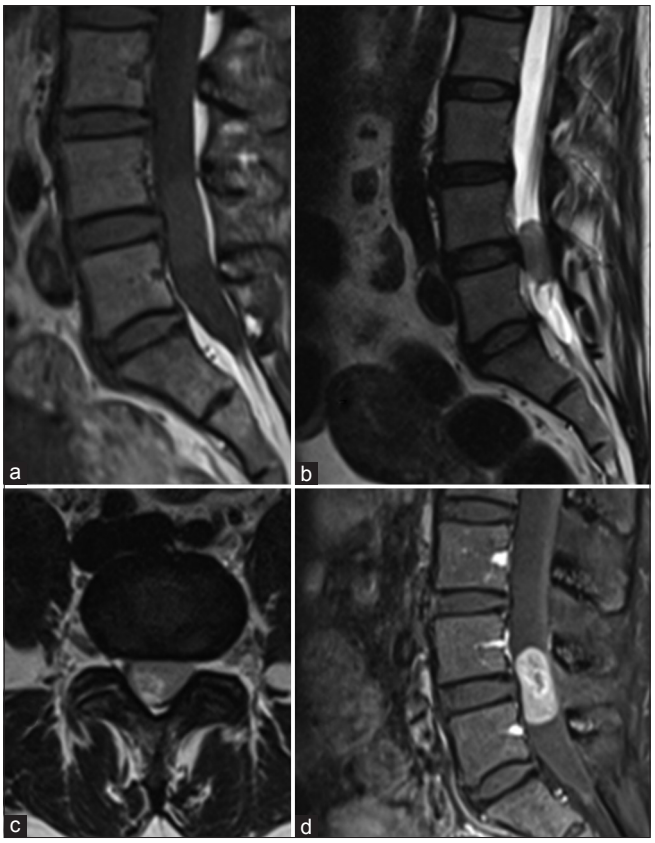


Figure 2: (a) T1 sagittal image demonstrating an oval-shaped isointense intradural mass (b) T2 sagittal lesion appearing iso to hyperintense (c) T2 axial confirming intradural location (d) Postcontrast T1 fat-saturated sagittal image demonstrating heterogeneous postcontrast enhancement with eccentric nonenhancing area. Histopathology reveals schwannoma with eccentric necrosis

MRI findings of spinal meningiomas shared similarities with intracranial meningiomas. Spinal meningiomas typically were isointense to the cord on both T1WIs and T2WIs. They often had a broad base of dural attachment. T1WIs showed moderate-to-intense enhancement after contrast administration [Figure 3]. In a few cases of meningioma, an abnormal enhancement of the adjacent dura has been noted.[16,17] In the present study also, we noted two rare cases of extradural meningioma having appearance of a sheet-like extradural soft tissue in the spinal canal. They were isointense on T1WIs, iso to hyperintense on T2WIs, and demonstrated moderate homogeneous postcontrast enhancement [Figure 4].

Arachnoid cyst

Spinal arachnoid cysts present mostly in children and adolescents with a male preponderance. These are diagnosed as an incidental finding on MRI.[18] These cysts are commonly encountered on the posterolateral aspect of the thoracic spinal cord. Congenital lesions are thought to arise from a dural defect due to derangements of septum posticum which divides the subarachnoid space in the midline from the cervical to the lumbar region.[19-21] They usually develop as foramen-enlarging diverticula with a unidirectional ball-valve mechanism or may even be completely sealed from the surrounding CSF.[19] The cause of these cysts in majority of cases has not been determined, hence are idiopathic. Other causes maybe postoperative complication, lumbar myelography, meningitis with adhesions in the subarachnoidal space, and epidural hematoma after surgical removal. The patients present with variable symptoms based on location of the cyst in spinal cord and degree of cord compression. The clinical presentation may include gait disturbance, spastic paraparesis or tetraparesis, neuropathic pain, and bowel and bladder dysfunctions affecting patients' quality of life.[22]

As these cysts contained CSF, they had long T1 and T2 relaxation times and appeared isointense to the surrounding CSF.[23,24] These lesions did not show any contrast enhancement [Figure 5].

Lipoma

Intradural spinal lipoma is a rare spinal tumor presenting in the second to third decades of life, with symptoms related secondary to mass effect or compressive myelopathy.[25,26] These tumors can be present anywhere in the spinal canal.[25] In adults, the most common location is thoracic region, whereas in children, it is mostly located in cervical spine. The suffix "oma" implies a neoplastic event in the pathophysiology of the lesion.

These lesions typically demonstrated fat signal intensity appearing hyperintense on both T1WIs and T2WIs. The signal intensity showed reduction with fat-suppressed sequences with mild peripheral postcontrast enhancement [Figure 6].

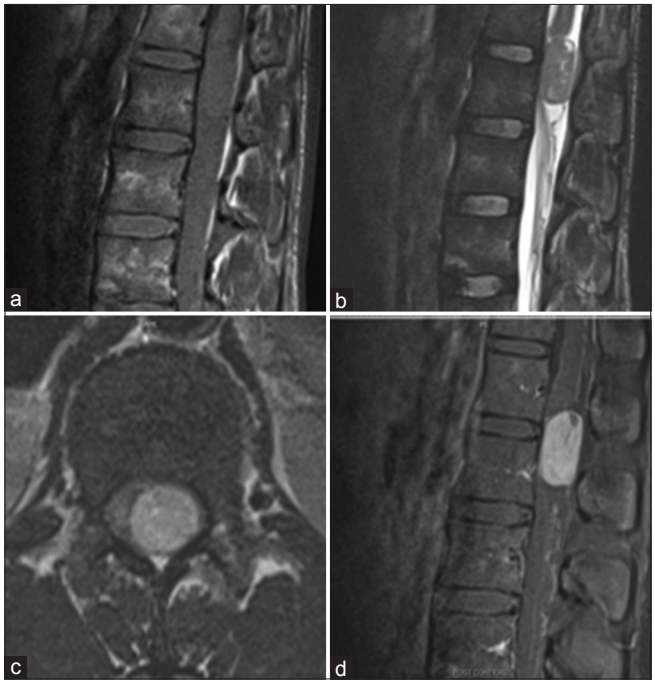


Figure 3: (a) T1 sagittal image demonstrating an oval-shaped isointense intradural mass (b) T2 sagittal lesion appearing iso to hypointense (c) T2 axial confirming intradural location (d) Postcontrast T1 fat-saturated sagittal image demonstrating avid homogeneous postcontrast enhancement. Histopathology reveals meningioma

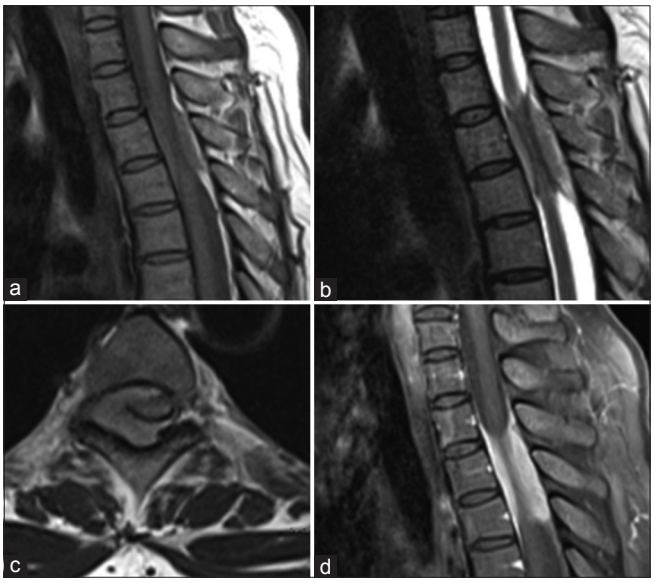


Figure 4: (a) T1 sagittal image demonstrating a sheet-like isointense epidural mass (b) T2 sagittal lesion appearing iso to hyperintense (c) T2 axial extradural lesion partially encasing and compressing the spinal cord. (d) Postcontrast T1 fat-saturated sagittal image demonstrating moderate homogeneous postcontrast enhancement. Histopathology reveals extradural meningioma

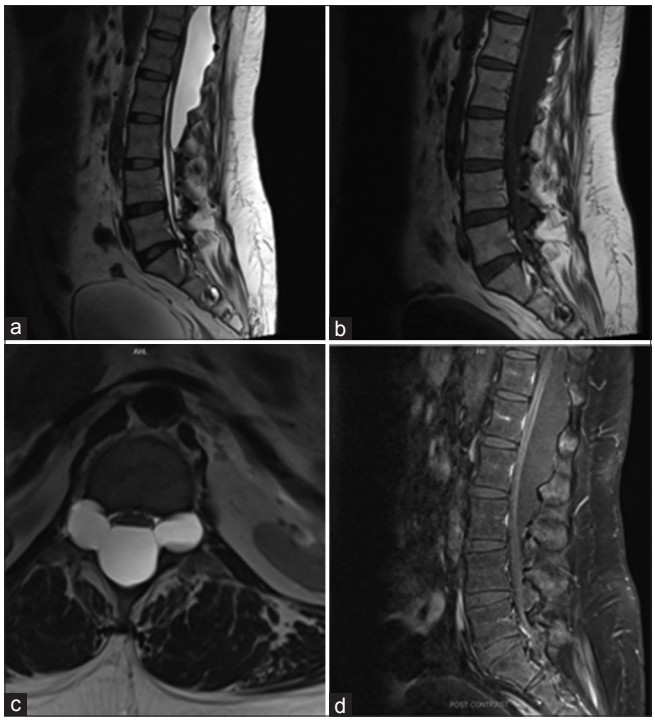


Figure 5: (a) T2 sagittal image demonstrating a hyperintense cystic-appearing lesion displacing and compressing the spinal cord (b) T1 sagittal lesion appearing hypointense (c) T2 axial intradural cerebrospinal fluid signal intensity lesion compressing the spinal cord (d) Postcontrast T1 fat-saturated sagittal image demonstrating no obvious postcontrast enhancement. Histopathology reveals arachnoid cyst

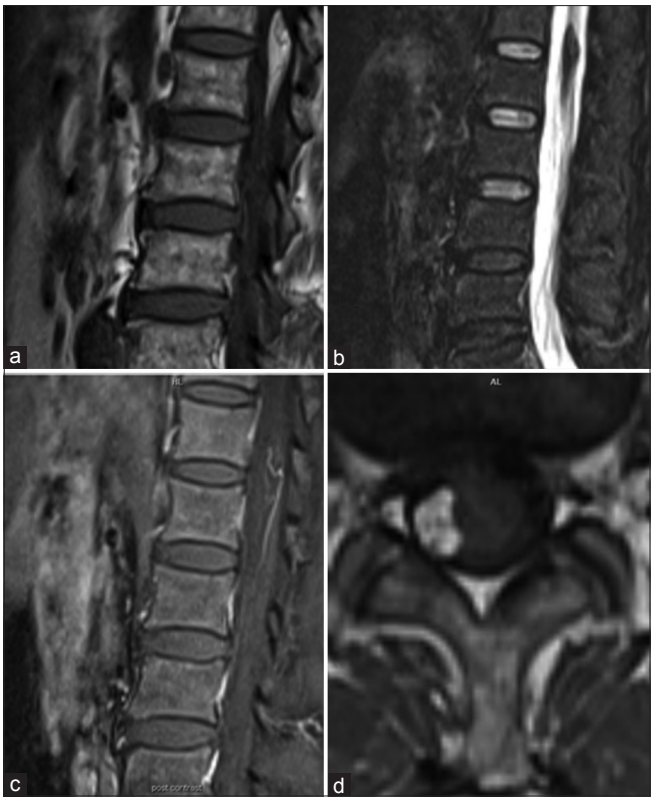


Figure 6: (a) T1 sagittal image demonstrating an oval hyperintense lesion (b) short-tau inversion recovery sagittal suppression of T1 hyperintensity suggestive of fatty nature of lesion (c) Postcontrast T1 fat-saturated sagittal image demonstrating mild peripheral postcontrast enhancement. (d) T2 axial hyperintense intradural lesion on the right side. Histopathology reveals intradural lipoma

Neurofibroma

Neurofibromas accounting for 23% of all spinal tumors present in the third to fourth decades of life with no sex predilection. Majority of solitary lesions are sporadic with a classic association of multiple lesions in patients of NF-1.[27] They can undergo various types of degeneration, usually hemorrhagic, fatty, and sometimes malignant degeneration. The treatment of choice is surgery.

Neurofibromas appeared isointense to hypointense to the spinal cord on T1WIs and hyperintense to the cord with central decreased intensity on T2WIs. This central T2WI hypointensity has been classically described as the "target sign," which is suggestive of neurofibromas but also noted in schwannoma.[28] Further, these lesions also demonstrated postcontrast enhancement [Figure 7]. The diagnostic difficulty was encountered in distinguishing solitary spinal neurofibroma from schwannoma based on imaging alone though cystic degeneration and hemorrhage were infrequently associated with neurofibroma. Involvement of a ventral nerve root with clinical presentation of radicular pain and dysesthesia was more suggestive of neurofibroma.

Malignant peripheral nerve sheath tumor

Malignant peripheral nerve sheath tumors are sarcomas taking their origin *de novo* from a peripheral nerve or from a preexisting neurofibroma, or cells associated with nerve sheath. These are tumors of adulthood with age ranging from 20 to 50 years, occurring spontaneously or in association with NF1. These are considered to be biologically aggressive soft-tissue sarcomas with potential complications of recurrence and metastasis. Infiltration of paravertebral soft tissues is a common feature of these tumors with a rare intraspinal involvement. Tumor masses are characterized by ill-defined margins, heterogeneity, and infiltration into the surrounding structures. Prognosis is poor with high relapse rate, poor response rate, and rapid disease progression.[4]

On T1WIs, these lesions showed heterogeneity with isointense signals, and on T2WIs, the lesions appeared to be heterogeneous with isointense-to-hyperintense signals relative to spinal cord. Postcontrast images revealed avid peripheral enhancement of these lesions [Figure 8].



Figure 7: (a) T1 sagittal image demonstrating an oval isointense mass compressing the spinal cord (b) T2 sagittal lesion appearing iso to hyperintense (c and d) T2 and T1 lesions causing significant cord compression. Histopathology reveals neurofibroma



Figure 9: (a) T1 fat-saturated sagittal image demonstrating an isointense sheet-like lesion in posterior epidural space (b) T2 sagittal lesion appearing isointense (c) T2 axial posterior epidural lesion compressing the spinal cord (d) Postcontrast T1 fat-saturated sagittal image demonstrating moderate homogeneous postcontrast enhancement. Histopathology reveals granulocytic sarcoma secondary to acute myeloid leukemia

Acute myeloid leukemia

Acute myeloid leukemia refers to malignant clonal proliferation of myeloid cells in the bone marrow.[29]



Figure 8: (a) T1 sagittal image demonstrating an irregular isointense mass (b) T2 sagittal lesion appearing heterogeneously hyperintense (c) T2 axial image demonstrating an extradural lesion compressing the thecal sac (d) Postcontrast T1 fat-saturated sagittal image demonstrating heterogeneous postcontrast enhancement. Histopathology reveals malignant peripheral nerve sheath tumor

Direct symptomatic leukemic infiltration of the spinal cord is quite rare and usual presentation is as a solid tumor composed of immature granulocytic cells. Hence, also named as granulocytic sarcoma or extramedullary myeloblastoma or chloroma.[30] These tumors can cause compression of nerve roots, spinal cord, or cauda equina.

On MRI, these lesions presented as epidural lesions mainly in the posterior epidural space, appearing hypointense on T1WIs and isointense on T2WIs with moderate homogeneous postcontrast enhancement [Figure 9]. Urgent neurosurgical intervention in the form of laminectomy and decompression was indicated to avoid any permanent neurological deficit.

Metastasis

Metastatic spinal tumors are associated with primary malignancies of prostate, thyroid, lung, kidney, and pancreas. CSF seeding with malignant cells via a hematogenous route or direct spread from a CNS primary may also result in spinal metastasis.[31] Tumors such as high-grade astrocytoma, ependymoma, germ cell tumor, medulloblastoma, and choroid plexus neoplasm metastasize through CSF dissemination.

MRI findings were similar to the pattern of disease involvement. These included solitary masses, diffuse or nodular coating of the cord and nerve roots, and thickening of the cauda equina appearing hypointense on T1WIs and iso to hyperintense on T2WIs [Figure 10]. Contrast-enhanced MRI is essential to detect all the spinal metastatic lesions.

MRI and lumbar puncture with CSF cytology have been increasingly used as diagnostic tests to identify spinal metastasis. Significant false-negative rate with a frequent need of multiple CSF examinations indicated lower sensitivity of cytology in diagnosing spinal metastasis. As chemical meningitis can cause enhancement and thickening of nerve roots, mimicking metastatic disease, so imaging should precede lumbar puncture and craniotomy.

Limitations of this study include its relatively small sample size and lack of long-term follow-up.

CONCLUSIONS

MRI is an indispensable tool in the evaluation of spinal pathologies. Its multiplanar capability, high-quality soft-tissue resolution, and depiction of various anatomic landmarks help in fairly accurate diagnosis of spinal neoplasms. This further guides the neurosurgeon to make a road map for the surgery. In most of the cases, MRI can give information regarding the histopathology of the lesion. However, in some cases, differential diagnosis needs to be included, especially in cases of extradural meningiomas and malignant peripheral nerve sheath tumors, because of their rare incidence.

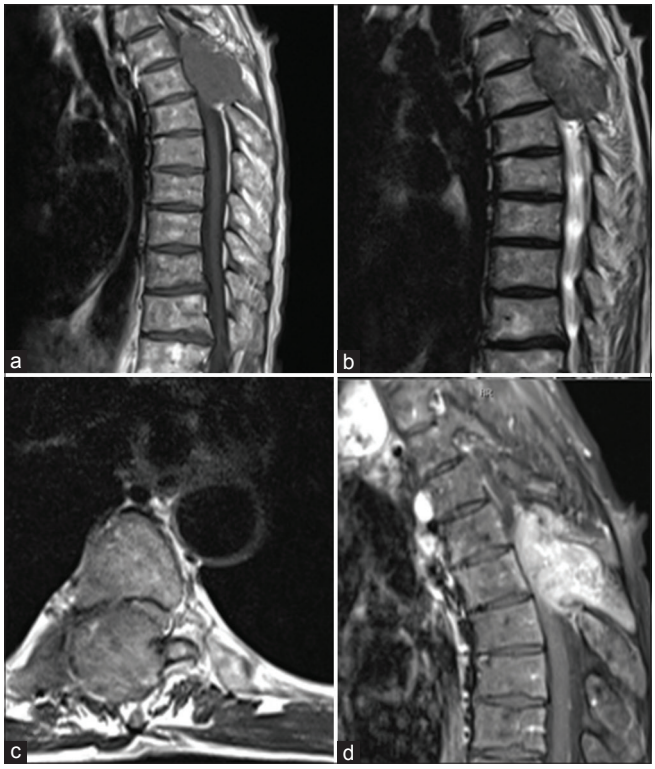


Figure 10: (a) T1 sagittal image demonstrating an irregular iso-to-hypointense mass compressing the spinal cord and infiltrating the overlying posterior elements of vertebral bodies (b) T2 sagittal lesion appearing hypointense (c) T2 axial lesion causing significant cord compression as well as overlying posterior element infiltration. (d) Postcontrast T1 fat-saturated sagittal image demonstrating moderate heterogeneous postcontrast enhancement. Histopathology reveals metastasis from thyroid malignancy

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Porchet F, Sajadi A, Villemure JG. Spinal tumors: Clinical aspects, classification and surgical treatment. Schweiz Rundsch Med Prax 2003;92:1897-905.
2. Hufana V, Tan JS, Tan KK. Microsurgical treatment for spinal tumours. Singapore Med J 2005;46:74-7.
3. Albanese V, Platania N. Spinal intradural extramedullary tumors. Personal experience. J Neurosurg Sci 2002;46:18-24.
4. Carra BJ, Sherman PM. Intradural spinal neoplasms: A case based review. J Am Osteopath Coll Radiol 2013;2:13-21.
5. Kocher B, Smirniotopoulos JG, Smith AB. Intradural spinal lesions. Appl Radiol 2009;9.
6. McCormick PC, Post KD, Stein BM. Intradural extramedullary tumors in adults. Neurosurg Clin N Am 1990;1:591-608.
7. Intradural, Extramedullary, Schwannoma. Available from: http://www.diagnosticimaging.com/case-studies/intradural-extramedullary-schwannoma#sthash.rMtLryUh.dpuf. [Last accessed on 2017 Apr 12].
8. Ross JS, Moore KR, Shah LM, Borg B, Crim J. Neoplasms, cysts, and other masses: Neoplasms. Diagnostic Imaging Spine. 2nd ed. Manitoba, Canada: Amirsys; 2010. p. 84-87.
9. Frank BL, Harrop JS, Hanna A, Ratliff J. Cervical extradural meningioma: Case report and literature review. J Spinal Cord Med 2008;31:302-5.
10. Salehpour F, Zeinali A, Vahedi P, Halimi M. A rare case of intramedullary cervical spinal cord meningioma and review of the literature. Spinal Cord 2008;46:648-50.
11. Sahni D, Harrop JS, Kalfas IH, Vaccaro AR, Weingarten D. Exophytic intramedullary meningioma of the cervical spinal cord. J Clin Neurosci 2008;15:1176-9.
12. Arnautovic K, Arnautovic A. Extramedullary intradural spinal tumors: A review of modern diagnostic and treatment options and a report of a series. Bosn J Basic Med Sci 2009;9 Suppl 1:40-5.
13. Saydam O, Senol O, Schaaij-Visser TB, Pham TV, Piersma SR, Stemmer-Rachamimov AO, *et al*. Comparative protein profiling reveals minichromosome maintenance (MCM) proteins as novel potential tumor markers for meningiomas. J Proteome Res 2010;9:485-94.
14. Solero CL, Fornari M, Giombini S, Lasio G, Oliveri G, Cimino C, *et al*. Spinal meningiomas: Review of 174 operated cases. Neurosurgery 1989;25:153-60.
15. Levy WJ Jr., Bay J, Dohn D. Spinal cord meningioma. J Neurosurg 1982;57:804-12.
16. Matsumoto S, Hasuo K, Uchino A, Mizushima A, Furukawa T, Matsuura Y, *et al*. MRI of intradural-extramedullary spinal neurinomas and meningiomas. Clin Imaging 1993;17:46-52.

17. Quekel LG, Versteege CW. The "dural tail sign" in MRI of spinal meningiomas. J Comput Assist Tomogr 1995;19:890-2.
18. Kumar K, Malik S, Schulte PA. Symptomatic spinal arachnoid cysts: Report of two cases with review of the literature. Spine (Phila Pa 1976) 2003;28:E25-9.
19. Silbergleit R, Brunberg JA, Patel SC, Mehta BA, Aravapalli SR. Imaging of spinal intradural arachnoid cysts: MRI, myelography and CT. Neuroradiology 1998;40:664-8.
20. Andrews BT, Weinstein PR, Rosenblum ML, Barbaro NM. Intradural arachnoid cysts of the spinal canal associated with intramedullary cysts. J Neurosurg 1988;68:544-9.
21. Khosla A, Wippold FJ 2nd. CT myelography and MR imaging of extramedullary cysts of the spinal canal in adult and pediatric patients. AJR Am J Roentgenol 2002;178:201-7.
22. Petridis AK, Doukas A, Barth H, Mehdorn HM. Spinal cord compression caused by idiopathic intradural arachnoid cysts of the spine: Review of the literature and illustrated case. Eur Spine J 2010;19 Suppl 2:S124-9.
23. Secer HI, Anik I, Celik E, Daneyemez MK, Gonul E. Spinal hydatid cyst mimicking arachnoid cyst on magnetic resonance imaging. J Spinal Cord Med 2008;31:106-8.
24. Beall DP, Googe DJ, Emery RL, Thompson DB, Campbell SE, Ly JQ, *et al*. Extramedullary intradural spinal tumors: A pictorial review. Curr Probl Diagn Radiol 2007;36:185-98.
25. Shen SH, Lirng JF, Chang FC, Lee JY, Luo CB, Chen SS, *et al*. Magnetic resonance imaging appearance of intradural spinal lipoma. Zhonghua Yi Xue Za Zhi (Taipei) 2001;64:364-8.
26. Blount JP, Elton S. Spinal lipomas. Neurosurg Focus 2001;10:e3.
27. Levy WJ, Latchaw J, Hahn JF, Sawhny B, Bay J, Dohn DF. Spinal neurofibromatosis: A case report of 66 cases and a comparison with meningiomas. Neurosurgery 1986;18:331-4.
28. Murphey MD, Smith WS, Smith SE, Kransdorf MJ, Temple HT. From the archives of the AFIP. Imaging of musculoskeletal neurogenic tumors: Radiologic-pathologic correlation. Radiographics 1999;19:1253-80.
29. Pileri SA, Ascani S, Cox MC, Campidelli C, Bacci F, Piccioli M, *et al*. Myeloid sarcoma: Clinico-pathologic, phenotypic and cytogenetic analysis of 92 adult patients. Leukemia 2007;21:340-50.
30. Frohna BJ, Quint DJ. Granulocytic sarcoma (chloroma) causing spinal cord compression. Neuroradiology 1993;35:509-11.
31. Wasserstrom WR, Glass JP, Posner JB. Diagnosis and treatment of leptomeningeal metastases from solid tumors: Experience with 90 patients. Cancer 1982;49:759-72.