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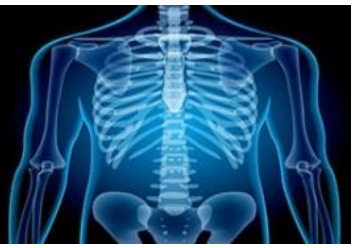

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Evaluation of non-traumatic myelopathy using magnetic resonance imaging

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Abstract
Background: Prompt and concise diagnosis of etiologic agent behind Non-Traumatic Myelopathy (NTM) and localization of the site of lesion are essential for prediction of neurological and functional outcomes. Magnetic Resonance Imaging (MRI) plays a key role in evaluation of myelopathy.
Objectives: The objective of the present study was to characterize the spinal cord lesions in Non-traumatic Myelopathy and to evaluate the etiological factors leading to NTM.
Materials and Methods: A hospital based cross-sectional study was done from November 2017 to May 2019 in a tertiary care centre of South India, where 85 patients with clinical suspicion of NTM were evaluated with MRI of spine. The MRI data collected was analyzed and described.
Results: Out of 85 patients in our study group, 44 (51.8%) were males and 41 (48.2%) were females, without any significant gender predilection. The age group ranged from 5 to 83 years, with majority of patients in the 7th decade (25.9%). Degenerative myelopathy was the most common etiology accounting for 57.6% of the patients, followed by infective (28.2%), primary neoplastic (9.4%), congenital (1.1%), demyelinating (1.1%), metastatic (1.1%) and nutritional (1.1%) etiologies.
Conclusion: MRI characteristics of the most common lesions were sufficiently distinct to allow them to be differentiated from each other and from most other entities. Other characteristics such as extradural versus intradural, intramedullary versus extramedullary, nature of enhancement on Post Gadolinium study, the presence of epidural, prevertebral and paravertebral involvement permit further differentiation among the various other abnormalities. MRI is a very sensitive, specific, non-invasive radiation-free modality for evaluation of NTM.

Keywords: Myelopathy, non-traumatic, spinal cord, magnetic resonance imaging

Introduction
Myelopathy describes any neurological deficit related to the spinal cord [1]. Damage to the spinal cord results in neurological impairment affecting motor, sensory and autonomic functions. Anatomically the lesions can be classified as extradural, intradural-extramedullary and intramedullary lesions [2]. Myelopathy can result from traumatic or non-traumatic causes. The pathogenesis of non-traumatic spinal cord injury/disease (SCI/D) can be divided into compressive and non-compressive causes, which includes vertebral spondylosis, neoplasms, infections, vascular ischemia, multiple sclerosis, motor neuron disease, radiation myelopathy, syringomyelia, paraneoplastic syndrome and vitamin B12 deficiency. The incidence, demographics, clinical presentations and outcomes for the non-traumatic SCI/D population has not been as thoroughly studied as in persons with traumatic SCI. In the international literature, MRI-based population studies have revealed that more than 85% of the adults aged above 60 years had degenerative myelopathy. Average age at diagnosis was 64 years. Degenerative myelopathy is more common in men as compared to women with a ratio of 2.7:1 [3]. Prompt and concise diagnosis of these etiologies and localization of the site of lesion are essential for prediction of neurological and functional outcomes. A better understanding of these entities will assist in the medical management, rehabilitation and long-term follow up for these individuals [4]. MRI is the mainstay in evaluation of myelopathy. It has improved imaging of the spinal cord lesions to a point that reliable diagnosis of even a non-expansile lesion is routinely possible [5].
Post Gadolinium (Gd) contrast study was performed in few patients, wherever necessary after injecting 0.1 mmol/kg body weight of intravenous Magnevist (Gadopentetate Dimeglumine and Post Gd-T1FS images were obtained in axial, coronal and sagittal planes.

Statistical analysis

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation.

Results

Out of 85 patients in our study group, 44 (51.8%) were males and 41 (48.2%) were females, without any significant gender predilection. The age group ranged from 5-83 years, with majority of patients in the 7th decade (25.9%).

Degenerative etiology accounted for 57.6% of patients, followed by infective causes (28.2%), primary neoplasms (9.4%) and metastasis (1.1%). Rest of the cases had a congenital (1.1%), nutritional (1.1%) or a demyelinating (1.1%) etiology. (Figure.1)

Extradural compartment was affected in 87.1% of the patients, 5.9% had involvement of extramedullary-intradural compartment and 7.1% had involvement of purely the intramedullary compartment (Figure.2). 64.7% of the lesions were in the cervical region, 16.4% at Lumbar + thoracic region and 9.4% were exclusively in the thoracic region. Considering patients with infective spondylosis, 60.9% had lesions at lumbar and thoracic regions, 17.4% at Lumbar region, 13% at thoracic region and 8.7% at cervical region. Out of 10 patients with neoplasms, 20% were extradural, 60% were extramedullary-intradural and 20% were intramedullary lesions. 30% of the tumours were located in the cervical region, 50% were thoracic and 20% were lumbar. 31.8% had pre and paravertebral space involvement. Posterior element involvement was seen in 2.4% cases.

Figure 1

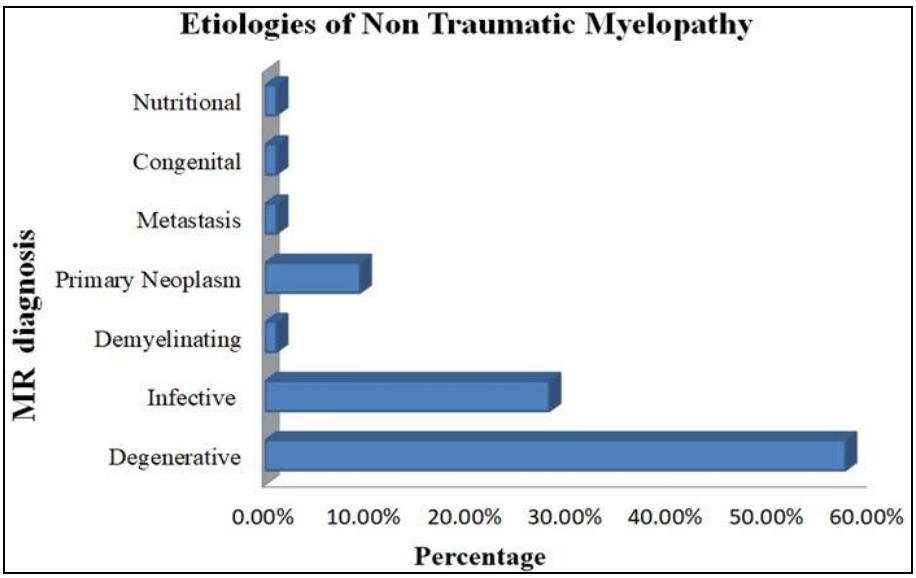

Fig 1: Bar diagram showing summary of all causes of Non-traumatic myelopathy

Figure 2

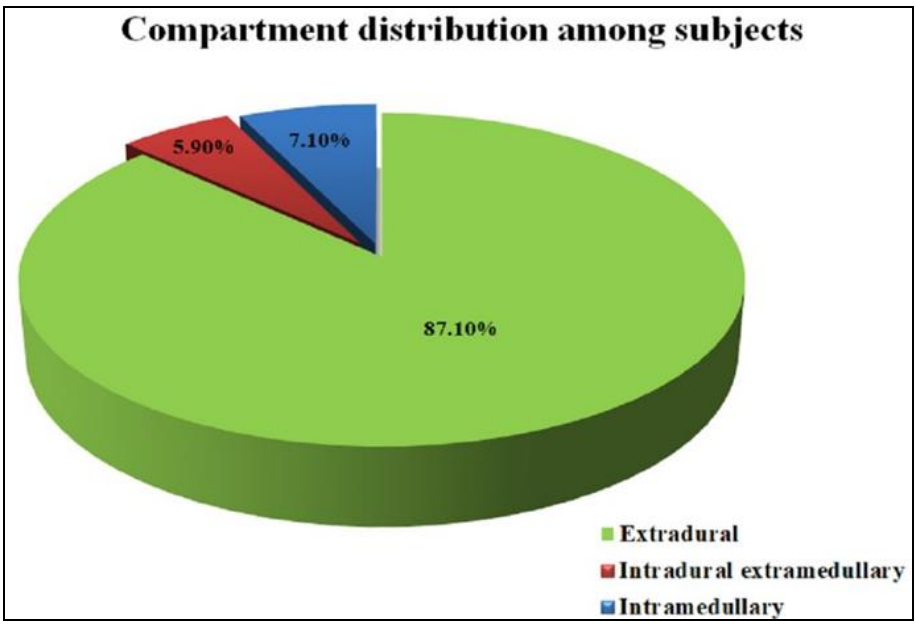

Fig 2: Pie diagram showing Compartment distribution among subjects

Discussion

MRI is a good imaging modality to evaluate for pathologies of spinal cord due to its ability to depict the anatomy and pathology in multiple planes without the use of radiation. It is non-invasive and has superior soft tissue contrast resolution.

The incidence, demographics, clinical presentations and outcomes for the non-traumatic SCI/D population has not been as thoroughly studied as in persons with traumatic SCI. Nouri *et al.* [6] did a narrative review and concluded the incidence and prevalence of degenerative myelopathy was about 41 and 605 respectively per 10,00,000 population in North America. Wu *et al.* [7] did a 12-year retrospective cohort study using the National Health Insurance Research Database and concluded the overall incidence of degenerative myelopathy related hospitalization was 4.04 per 1,00,000 person-years in Taiwan, with a higher incidence in elderly males. There has been no standard population-based study documenting the incidence and prevalence of degenerative myelopathy in India.

In the present study, majority of subjects were in the 6th and 7th decades (43.5%). In a study by Onwuchekwa *et al.*, [8] majority of patients presented in the 6th decade, accounting for 29.17%. Murray *et al.* [9] reported that non-traumatic SCI comprises only 31% of the patients under the age of 40 years but 87% of those over that age.

Out of 85 cases of NTM, degenerative etiology accounted for 57.6% of patients, followed by Infections (28.2%), primary neoplasms (9.4%) and metastasis (1.1%). Rest of the cases had a congenital (1.1%), nutritional (1.1%) or a demyelinating (1.1%) etiology. In a study conducted by Chaurasia *et al.*, [10] infective spondylosis accounted for majority of the cases (35.7%) followed by degenerative myelopathy (34.1%). Moore *et al.* [11] revealed degenerative myelopathy (23.6%), as a major cause of NTM followed by multiple sclerosis (17.8%), extrinsic spinal cord neoplasia (16.4%) and motor neuron disease (4.1%).

The most common level of involvement of lesions in our study were in the cervical region (64.7%) followed by thoraco-lumbar region (16.4%). This was in contrast to the study by Onwuchekwa *et al.* [8] who reported majority of lesions in the thoracolumbar region (37.0%). Pre and paravertebral space involvement was noted in 27 cases (31.8%). Majority of them, were secondary to Pott's spine (28.2%). Posterior elements were involved in two cases (2.4%), one being hemangioendothelioma and another was a patient with spinal metastasis.

IV Gadolinium was used in 33 patients (38.8%). Those with Pott's spine demonstrated mild rim enhancement. Spinal metastasis, schwannoma, hemangioendothelioma demonstrated moderate heterogeneous enhancement. Meningiomas and neurofibroma had homogeneous enhancement. A case of Multiple Sclerosis plaque in the cervical cord showed ring enhancement.

Majority of patients (57.6%) in our study had degenerative disc disease as the cause of myelopathy. It was most prevalent in the 7th decade (86.4%). The fact that degenerative myelopathy accounted for majority of the cases could be explained by the reflection of its involvement in the aging population who constituted a major portion of this study (Figure 3). Degenerative myelopathy was demonstrated as the predominant cause of NTM in previous studies conducted in Western countries by Scivoletto *et al.* [12] and Mckinley *et al.*[13] Similar findings were reported by Oguniyi *et al.* [14] in Nigerian population.

In the present study, we had 24 patients with infective spondylosis causing compressive myelopathy, all of them were Pott's spine. One patient had T2W hyperintense signal changes in the lower dorsal cord and conus medullaris suggesting Tubercular myelopathy. (Figure 4) It is estimated that involvement of the spine occurs in less than 1% of patients with tuberculosis [15] Pott's spine was the second most common cause of NTM in our study. Unlike in our study, Pott's spine accounted for majority of patients with NTM in most Indian studies [14]. Studies in other developing countries of Africa also showed Tuberculosis (TB) as the leading cause of NTM [16, 17]. The involvement of thoracolumbar spine as seen in 14 cases (60.9%) is in agreement with studies by Hodgson *et al.* [18] and New *et al.* [19] MRI showed vertebral body destruction with pre and paravertebral collections in all the cases. The cord compression resulted secondary to the epidural abscess in all cases with Infective spondylosis. Pott's spine was most prevalent in the third decade (66.7%). This is in good correlation with the study by Scrimgeour *et al.* [20]

Out of the 10 patients with spinal cord tumours, 20% were extradural, 60% were intradural-extramedullary and 20% were intramedullary lesions. 30% were cervical in location, 50% were thoracic and 20% were lumbar in location. In the extradural compartment, the tumours involved were spinal metastasis in a 66 year old male and a case of hemangioendothelioma in a 5 year old female. The spinal metastasis was noted involving the first lumbar vertebra and was compressing the conus medullaris. The primary tumour in this case was found to be from bronchogenic carcinoma. The lesion was T1 hypointense and T2/STIR hyperintense. The lesion had epidural, pre and paravertebral components.

We had a rare case of spinal hemangioendothelioma causing compressive myelopathy in a 5 year old child. MRI showed a large well-defined multi-loculated T1 and T2 heterointense lesion involving D7 vertebra and posterior elements with destructive collapse of the respective vertebral body. Multiple blood-fluid levels were noted in the lesion. Vertebra plana with gibbus deformity of thoracic spine was seen at this level (Figure 5).

We had 6 patients with intradural-extramedullary neoplasms in our study. One patient was a known case of Neurofibromatosis type 2 with a thoracic schwannoma causing compressive myelopathy and multiple small meningiomas not resulting in any cord signal changes. We had two other patients with meningioma causing compressive myelopathy over the cord. The other intradural-extramedullary neoplasms included a case each of neurofibroma, schwannoma and spinal arachnoid cyst. In a study by Agarwal *et al.* [21], out of 90 cases of compressive myelopathy, 5 cases were primary intradural and extramedullary lesions. 2 were neurofibroma and 3 were meningioma. The neurofibroma was hypointense on T1WI and hyperintense on T2WI with extension into the neural foramina and showed intense homogeneous enhancement on Post Gd-T1FS images. One of the meningiomas was hypointense on T1W and T2W images. Another case of meningioma was hypointense on T1W and showed heterogeneous signal intensity on T2W images. The lesions showed homogeneous enhancement on Post Gd-T1FS images.

The cases with schwannomas showed hypointense signal on T1WI and heterogeneous hyperintense signal on T2WI with

heterogeneous enhancement on Post Gd-T1FS images. Skolnik *et al.* [22] demonstrated the schwannomas to be iso to hypo on T1WI and heterogeneously hyperintense on T2WI. A case of spinal arachnoid cyst in our study demonstrated CSF signal intensity on T1 and T2WI and showed inversion on Short Tau Inversion Recovery (STIR) images.

In the present study, we also encountered two intramedullary spinal neoplasms. One was a case of ependymoma in the cervical region and the other - a Myxopapillary ependymoma in the conus medullaris (Figure 6). The lesions were hypointense on T1W images and showed heterogeneous hyperintense signal on T2W images with moderate heterogeneous enhancement on Post Gd-T1FS images. Patchy DWI restriction was noted on DWI images.

We had a patient of Arnold Chiari Malformation Type 1 with long segment syringohydromyelia (Figure 7). The signal characteristics paralleled that of CSF on all sequences.

We had one patient with vitamin B12 deficiency, who clinically presented with breathlessness, numbness in hands and feet and glossitis. MRI of the cervical spine revealed bilateral symmetric T2 hyperintense signal intensities involving the posterior columns giving an inverted 'V' appearance (Figure 8).

We also had a patient who was a known case of Multiple Sclerosis with cord myelopathy. The plaque was seen for a short segment at the level of C4 vertebra with signal changes in the left hemicord. On post contrast study, mild to moderate homogenous enhancement was noted. There was no associated cord edema. (Figure 9).

Our study was not without limitations. The sample size was small due to the short duration of the study. The patients with incomplete data were excluded from the study. Further studies on cord myelopathy using a larger sample size is necessary to ascertain the common causes of NTM and its burden in the developing countries.

Figure 3

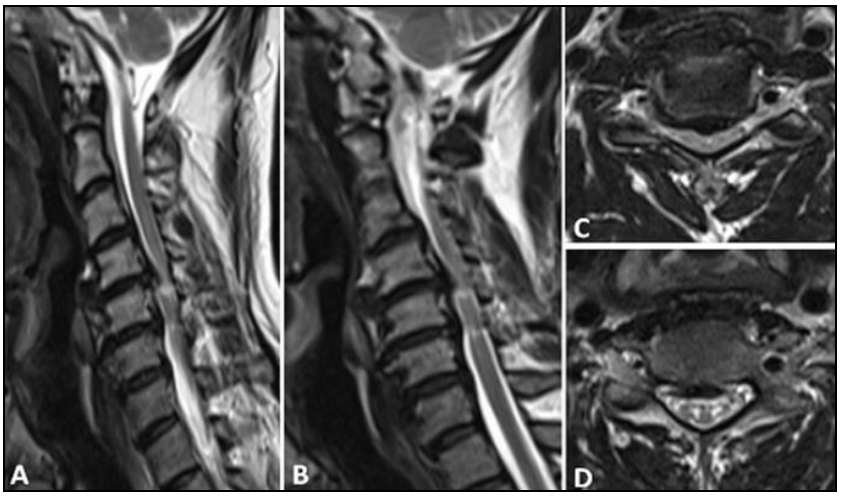

Fig 3: Degenerative Myelopathy: T2W sagittal (A,B) and axial (C,D) MRI Cervical spine images show posterior disc-osteophyte complexes at C4-5 and C5-6 levels causing thecal sac compression and moderate spinal canal stenosis leading to focal compressive cord myelopathy with syrinx formation at C4-5 (C) and C5-6 (D) levels.

Figure 4

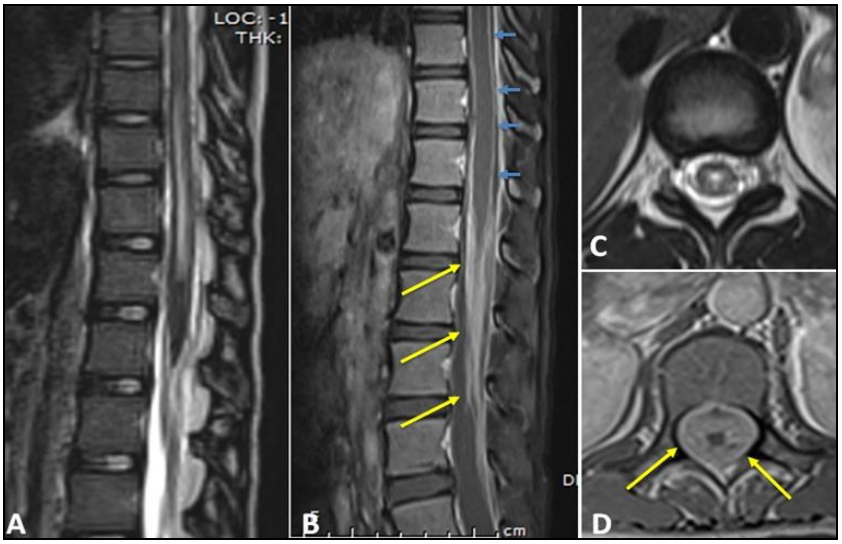

Fig 4: Tubercular myelopathy: Sagittal T2W (A) MRI image shows long segment T2 hyperintense signal changes in lower dorsal cord from D9 to D12 vertebral levels. T2 axial (C) image shows holocord involvement. No evidence of cord expansion seen. Post Gd-T1FS Sagittal and axial images (B, D) show thickened, clumped and enhancing cauda equina nerve roots suggesting arachnoiditis (yellow arrows). There is also enhancement along the surface of the spinal cord suggesting lepto-meningeal enhancement (short blue arrows)

Figure 5

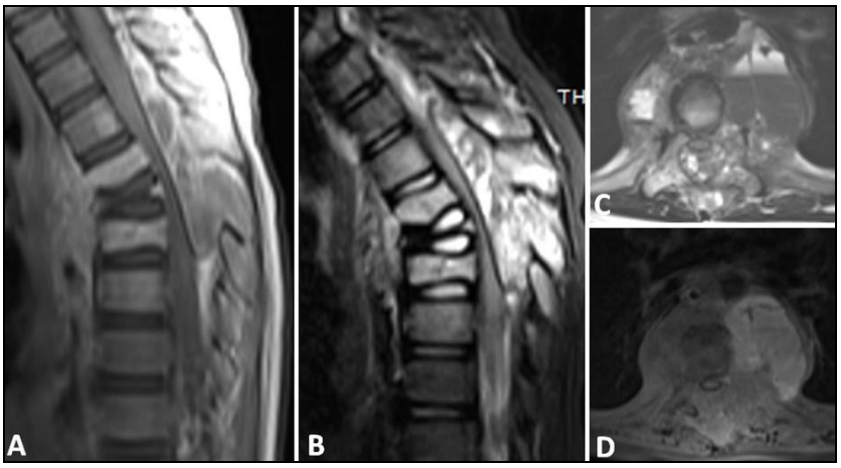

Fig 5: Hemangioendothelioma. Sagittal T1W (A), STIR (B) and Axial T2 (C), Post Gd-T1FS (D) images show a well-defined T1 and T2/STIR heterointense extradural mass lesion at the level of D4 to D9 vertebrae. There is collapse of D7 vertebral body with reduced heights of D6 and D8 vertebrae and altered signal intensities from D6 to D9 vertebrae. The intervening disc heights and signal intensities are preserved. The lesion is extending into posterior epidural space causing severe spinal canal stenosis and cord impingement with STIR hyperintensities in the dorsal cord. The lesion has large pre and paravertebral components. Post Gd-T1FS study shows moderate to intense heterogenous enhancement. T2 axial image shows multiple blood-fluid levels within (C). Gibbus deformity is seen at D7 vertebral level.

Figure 6

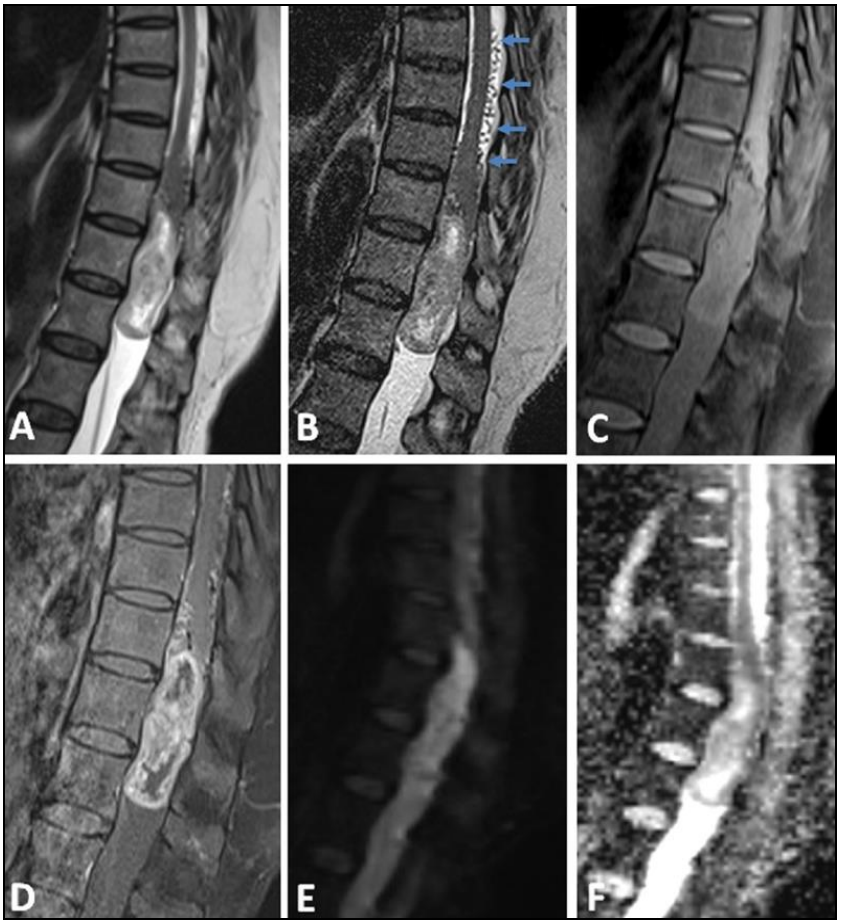

Fig 6: Myxopapillary Ependymoma. T2 sagittal MRI image (A) shows a well-defined heterointense lesion involving conus medullaris at the level of D11- L1 vertebrae. Sagittal 3D T2-Space image (B) shows multiple tiny flow voids (short blue arrows) in the posterior thecal space of lower dorsal spinal canal suggesting prominent dilated veins secondary to severe spinal canal stenosis by the lesion in conus medullaris. Few areas of blooming noted on GRE images (C) suggestive of microbleeds/ calcifications. Post Post Gd-T1FS study shows moderate heterogenous of the lesion with areas of necrosis within. Tiny enhancing foci are noted in the thecal space suggesting the dilated dural veins. Diffusion with ADC (E, F) images show patchy areas of DWI restriction in the lesion.

Figure 7

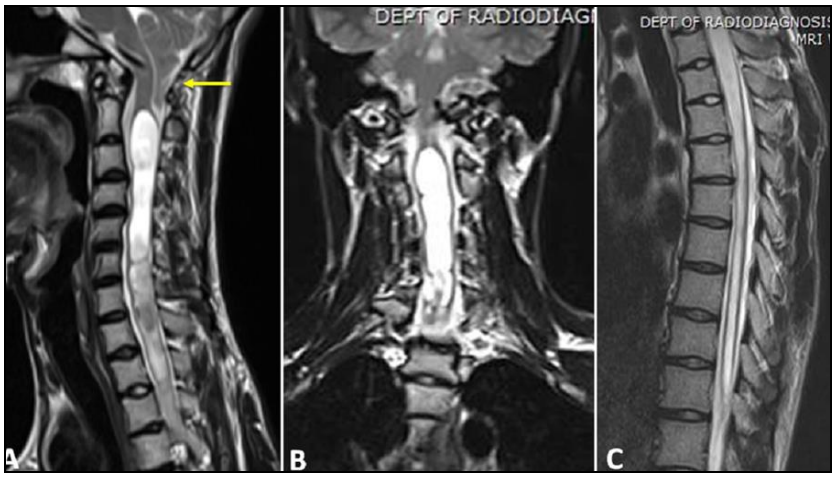

Fig 7: Arnold chiari malformation type I with syringomyelia: T2W Sagittal and Coronal MRI images show descent of cerebellar tonsils below the foramen magnum causing cervico-medullary junction stenosis and T2 hyperintense long segment syrinx formation with cord expansion involving nearly the whole length of spinal cord.

Figure 8

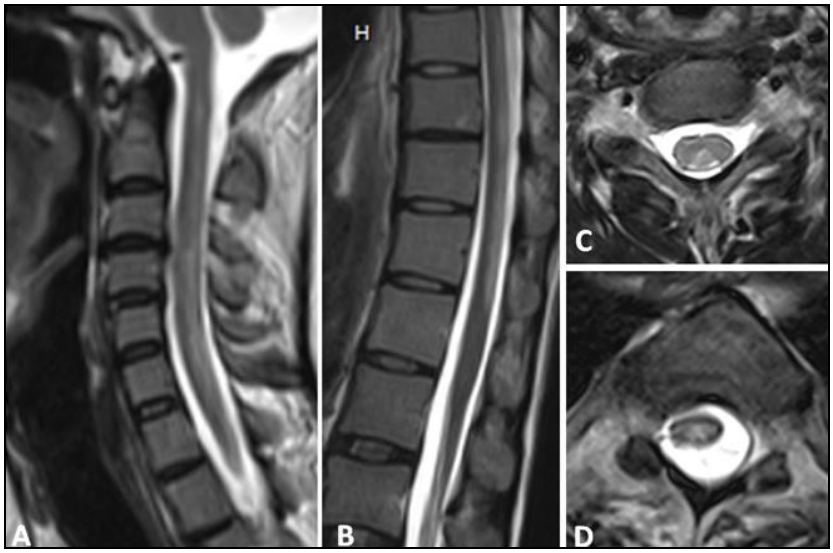

Fig 8: Subacute combined degeneration of the cord. T2 Sagittal MRI cervical spine image (A) shows long segment hyperintensity involving the cervical cord. Axial T2W images (C) show bilateral symmetric T2 hyperintensities in dorsal columns of spinal cord resembling an 'inverted V' pattern. T2 Sagittal MRI thoracolumbar spine image (B) shows long segment hyperintensity involving the lower dorsal spinal cord. Axial T2W images (D) show bilateral symmetric T2 high signal intensities within the dorsal columns of thoracic spinal cord resembling an 'inverted V' pattern.

Figure 9

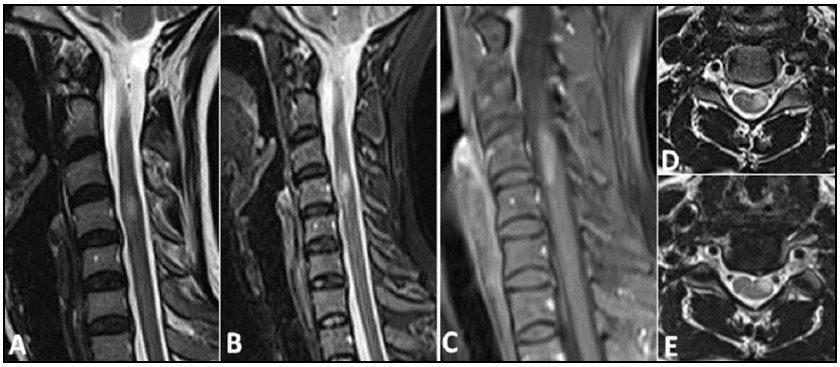

Fig 9: Multiple sclerosis. Sagittal T2 (A) and STIR (B) cervical spine images show T2 and STIR hyperintense lesion in the spinal cord at the level of C4 vertebral body. Homogenous enhancement noted on Post Gd-T1FS image (C). Axial T2 image (D) and (E) shows that the lesion is involving the left hemicord for a circumference of less than 50% of the area of the spinal cord.

Conclusion

MRI is an excellent modality for detection of pathologies of spine due to its superior soft tissue contrast resolution and multiplanar capacity. Knowledge of the normal anatomy and imaging appearance of various spinal cord lesions is essential in the interpretation of MR images of the spine. In the current practical scenario, MRI is the best technique that provides a detailed anatomical and pathological evaluation of the spinal cord. The wide spectrum of myelopathic disorders often present with similar symptoms. Accurate imaging characterization and early diagnosis are capable of providing significant clinical benefit.

Conflicts of Interest: The authors declare that we have no conflicts of interest.

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