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"MRI IMAGING OF CHRONIC SPINAL CORD INJURY"

KEYWORDS: Myelomalacia, cord atrophy, cord transaction, Wallerian degeneration

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ABSTRACT ***Aim:*** *To study the profile of MRI findings in patients with chronic spinal cord injury and correlate the MR imaging features to categorize chronic injuries into different types so as to allow appropriate treatment and prognostication which differs in different entities.*

Materials and methods: *This was a prospective study where twenty patients presenting with new/worsening neurological symptom in chronic phase (>6 months) of prior spinal cord injury (which had resulted in variable degree of neurological deficit), were evaluated with magnetic resonance imaging (MRI)*

Result: *Cord myelomalacia was the most common MRI finding and was typically present focally at the site of impact of trauma. Atrophy of the cord was seen distal to the initial cord injury. Cord transection evolved into cystic changes at the site of initial injury. Post traumatic cysts were more common in the thoracic cord. Wallerian degeneration was recognized as hyperintense signal seen in dorsal columns above the level of initial cord injury and was seen in high percentage of patients.*

Conclusion: *Chronic Posttraumatic myelopathy has varied spectrum which can be indentified and categorized well by MRI.*

Introduction

Spinal cord injury is a devastating insult leaving the afflicted patient with functional loss and dependence on others. Traumatic spinal cord insult may have spectrum ranging from cord compression, cord edema, contusion, hemorrhage or cord transaction and the extent of these findings determines the neurological functional outcome in acute stage.[1] MRI remains the mainstay of diagnosing spinal cord injury which will reveal not only the site and length of cord injury but also the type of injury, which is important in view of different levels of neurological recovery and prognosis.[2,3,4] MRI may be normal in few patients despite neurological deficits.

Apart from extent of damage to spinal cord at the time of injury the neurological status also depends upon the evolution of injury in subsequent period. Patients may have static neurological deficits for a long period after injury and later may show deterioration in chronic stage or continue to have progressive deterioration by development of chronic degenerative Wallerian degeneration, syrinx, cystic myelopathy, myelomalacic myelopathy, atrophy or cord adhesions.

Neurological deterioration in acute phase may improve if any compressive pathology is treated surgically. Neurological deterioration in chronic phase may improve if the condition is amenable to surgical treatment as in cystic myelopathy, syrinx, cord adhesions or in presence of persistent cord compression. However in other conditions like atrophy the outcome remains to be poor.

In chronic phase patient may remain neurologically stable or may deteriorate. The patient in whom deterioration occur are said to be affected by post traumatic progressive myelopathy. The cause of this type of myelopathy may be the development of atrophy or evolution into conditions like myelomalacia (progressive post traumatic myelomalacic myelopathy), spinal cord cyst (progressive post traumatic cystic myelopathy), syrinx or formation of intradural adhesions.

Materials and methods:

The study was conducted in the department of Radiodiagnosis, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, 20 patients presenting with new/worsening neurological symptom in chronic phase (>6 months) of prior spinal cord injury (which had resulted in variable degree of neurological deficit), were evaluated by magnetic resonance imaging (MRI). Patients of all age groups and both sex with previous spinal injury which resulted in some degree of motor/sensory deficit were included in the study. Patients with spinal injury in the form spinal fractures only with no associated neurological deficit were not included. Patients who had recent trauma (<6 months), were also excluded.

A detailed history of patients, previous MRI images and other investigations like spine radiographs/CT were recorded.

Methods

All cases were subjected to routine MRI on 1.5 Tesla 16 channel Achieva (Philips Medical system) MRI with SENSE body coil. Two sagittal sequences through whole spine including T1W sequence (FOV 160, TR-400ms, TE-8ms, slice thickness-4mm), T2W sequence (TR-3000ms, TE-120ms, slice thickness 4mm) were taken along with T1/T2 axial sequence through the abnormal area, STIR coronal sequence (FOV 150mm, TR-11000, TE-140, slice thickness 5mm) were also obtained

MRI findings were recorded, correlated with clinical findings, age, level of injury and type of cord lesion. Signal characteristics of type of cord lesion on MRI were studied and categorization into different chronic injuries done.

RESULTS

Time of presentation varied from 6 months to 2 years. The patients ranged in age from 14 to 65 years. They were referred either because of clinical deterioration or because of the development of new clinical symptoms and signs. Some patients were referred for an opinion regarding their prognosis. Motor and sensory loss, increase in spasticity, local pain and variable involvement of bladder and bowel were common symptoms. Paraparesis / paraplegia and quadreparesis / quadriplegia were the most common signs.

10 patients had been initially treated by surgical intervention such as discoidectomy / corpectomy followed by anterior fusion, lamin-

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ectomy, or posterior stabilization by transpedicular screw and rod fixation. All patients had been previously evaluated by different diagnostic procedures such as plain radiographs, CT or MRI.

The most common cause of injury was motor vehicle accidents and the most common type of injury was fracture and/or subluxation of spine. Cervical spine was the most common site.

The time interval until development of new symptoms was independent of the type of cord lesion. Of 20 patients who were assessed with MRI all cases were associated with medullary lesions.

Level of injury	Post traumatic syrinx	Post traumatic cysts	Myelo malac ia	Atroph y	Persistent compressi on	Cord transecti on
Cervical (13cases)	1	1	11	2	3	1
Thoracic (7 cases)	1	3	3	1	2	1
Total	1	4	14	3	5	2

Table I summarizes different pathologies according to the level and type of injury.

Cervical cord injury was seen in 13 (65%) and thoracic cord injury was seen in 7 (35%) of all cases. A variety of imaging findings were detected. They included myelomalacia in 14 (70%), cord cysts in 4 (20%), cord atrophy 3 (15%), cord transection in 2 (10%) and post traumatic syrinx in 1 (5%) of all cases. Persisting canal stenosis with variable degrees of cord compression were noted in 5 patients secondary to herniated disc, fibrosis, retropulsed bony fragment or subluxation.

Cord myelomalacia was the most common MRI finding and was typically present focally at the site of impact of trauma.

Of all the three patients having atrophy of the cord, myelomalacia was present at the site of insult and atrophy was seen distal to it. One of the patients had severe distal cord atrophy with cord attaining the size of a strand of hair. Both of the two patients of cord transection had associated cystic changes in the cord. Post traumatic cysts were more common in the thoracic cord.

In addition to these findings, 12 (60%) patients showed hyperintense signal in dorsal columns above the level of injury s/o Wallerian degeneration.

Image 1 -Spinal cord cyst at cord transection site – focal rounded areas of CSF signal.

Image 2- Myelomalacia- Mild intramedullary T2 hyperintensity with signal not paralleling signal of CSF

Image 3-Severe diffuse thinning of spinal cord s/o atrophy

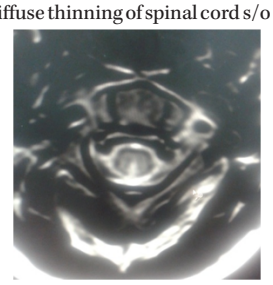

Image 4 - Hyperintense signal in dorsal columns indicating wallerian degeneration.

Discussion

MRI presentation of chronic phase spinal cord injury has variable picture explained in detail as below.

Spinal cord cyst forms at the site of previous trauma and may cause progressive neurological deficit with the condition known as post traumatic cystic myelopathy. On MRI the posttraumatic spinal cord cyst appears to be hypointense to the cord on T1W images, hypointense relative to the cord on moderately T2-weighted images and hyperintense on the more heavily T2-weighted images (Image 1). These patients may benefit from shunting of the cyst into subarachnoid space.[5,6,7,8]

Posttraumatic syringomyelia (PTS) refers to the formation and progression of a CSF filled cystic cleft within the spinal cord. PTS is an uncommon complication in which patient may present many years after the initial spinal cord injury by the insidious progression of pain and loss of sensorimotor function. Radiologically syrinx is seen as a very well defined linear intramedullary CSF intensity on T2 weighted images. It has to be differentiated from cystic myelomalacia in which a rim of hyperintensity is present in relation to the cystic component on T2 weighted images, and the cystic component is usually small. Patients of PTS may benefit from shunting of the syrinx especially in patients with cysts larger than 2cm and in symptomatic cysts.[6,7]

Spinal cord myelomalacia or progressive post traumatic myelomalacic myelopathy (PTMM) can also cause delayed and progressive neurological deterioration in the form of progressive motor loss or changes in sensory level, increased spasticity or loss of bowel or bladder control. Differentiation from post-traumatic cystic myelopathy is important, as PTMM may be caused from extramedullary cord adhesions/tethering and might benefit from lysis /release of adhesions while PTCM may benefit from shunting of the cyst.9,10 PTMM appears as a lesion with low signal intensity within the cord on the T1-weighted images and slightly more intense than the surrounding cord on the moderately T2-weighted images while on heavily T2-weighted images showed signal which did not parallel the signal from the CSF in the adjacent subarachnoid space (Image 2).

Spinal cord atrophy represents axonal loss and invariably reflects poor prognosis. Cord atrophy occurs as consequence to a complex phenomenon related to the effects of dynamic inflammation which leads to demyelination, axonal injury, neuronal loss and Wallerian degeneration.10, 11 Spinal cord atrophy is defined as an abnormal narrowing of the spinal cord in the sagittal plane in two or more segments beyond the limits of vertebral injury. Cord atrophy on MRI

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is seen as cord thinning without accompanying signal changes (Image 3). Normal cord measures approximately 7mm in cervical region, 6mm in upper dorsal and 5mm in lower dorsal region.

Cord tethering can also be a cause of delayed myelopathy in patients with traumatic cord injury. On MRI adhesions are seen as focal area of cord appearing confluent with the dura. Release of the tethered cord should be considered in a patient presenting with delayed myelopathy when a posttraumatic syrinx is not found.[12]

Wallerian degeneration

Due to the injury to the axons by trauma, antegrade degeneration of axons and their myelin sheath begins to occur and is labelled as **Wallerian degeneration.** It starts as early as 8 days on histological studies and is usually evident as early as 7 weeks on MR. It is seen as altered signal, appearing hyperintense on T2W images in dorsal column above the level of injury (Image 4), such changes are better appreciated on axial images and such changes becoming more pronounced and discrete with progression of time. Similar altered signal can be seen in lateral columns below the level of injury.[13,14,15,16,17]

Identification of changes of Wallerian degeneration are important as its presence above the site of injury indicates that there was partial or total interruption of axons of dorsal column and Wallerian degeneration itself can be a cause of further neurological deterioration in chronic phase. Diffusion tensor imaging can detect Wallerian degeneration even when conventional MR fails to do so and shows that axonal degeneration is a continuous process occurring for years after cord injury.

Incidence of various types of chronic cord injuries varied in different studies. According to Silberstein, cord atrophy (43%) and syrinx (41%) were the most frequent imaging findings with cord compression seen in 24%, cystic myelomalacia in 15%, myelomalacia in 11% and normal spinal cord in18% respectively.[10]

While in study by Curati, the incidence of various chronic cord injuries was myelomalacia in 37%, a syrinx in 40%, persistent cord compression in 32% and atrophy in 18%.[18] Neurological changes after initial neurological stabilization are seen in patients with extended atrophy, malacia or a syrinx, not in those with only a cyst or cord disruption. Tethering is usually always associated with other lesions.

MR imaging appearance of various types of cord injuries in different phases is summarized in table 2.

Table 2

Chronic injury	
1.Post traumatic syrinx	T2- very well defined linear intramedullary CSF intensity extending beyond the confines of initial injury
2.Post traumatic cysts	Small focal well defined lesion appearing at site of previous injury : T1W -hypointense T2 weighted –markedly hyperintense with signal of CSF
3.Cystic myelomalacia	T2- small well defined rounded or elliptical area of intramedullary CSF intensity representing small cyst at the site of previous injury surrounded with a hyperintense rim
4.Myelomalacia	T1 – low signal, T2 weighted images - slightly more intense than the surrounding cord, but less than that of CSF
5.Atrophy	Cord thinning without accompanying signal changes
6.Adhesion	Focal area of cord appearing confluent with the dura
7.Persistent compression	Focal narrowing with adjacent persisting compressive cause
8.Wallerian degeneration	T2- hyperintense signal in dorsal column above the injury, Hyperintense signal in lateral column below the injury

Conclusion

Spinal cord injury is a devastating injury the neurological outcome of which is dependent not only upon the extent of initial damage but also upon evolution into various forms of chronic sequelae such as myelomalacia, syrinx, atrophy as well as Wallerian degeneration which itself is another independent cause of neurological deterioration. MRI patterned approach enables recognition of various sequelae and thus in treatment and prognostification.

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