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MRI in Evaluation of Spinal Trauma: Imaging Techniques, Correlation with Neurological Status and Clinical outcome

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Conflicts of Interest: Nil

Abstract

Aims and Objectives:

To evaluate the role of MRI as a non-invasive diagnostic tool in cases of spinal trauma and to correlate MRI findings with patients clinical profile according to ASIA impairment scale to assess whether any MRI findings at presentation is able to predict clinical outcome.

Material and Methods:

One hundred twenty four patients of spinal trauma were included in the study with or without neurological deficit at presentation. Prior to imaging, a standardised physical examination was carried out. We utilized the American Spinal Injury Association 2000 (ASIA) standards for clinical evaluation. Magnetic resonance images were analyzed and correlated with ASIA impairment scale.

Results:

The cord oedema without haemorrhage was the most common MR finding (41.5%). The others were sizable Focus of haemorrhage within the cord (33%), epidural hematoma (5.0%), and normal cord (26%). Majority of MR findings correlated well with clinical profile of the patient according to ASIA impairment scale. This study demonstrated that patients with presence of sizable focus of haemorrhage had larger cord edema and more severe grade of initial ASIA impairment scale (AIS) with poor recovery at follow up (P=0.032). Improvement in upper extremity was more than lower extremity. Severe cord compression was also associated with poor neurological outcome; however it was not statistically significant (P=0.149).

Conclusion:

From our study we conclude that MRI should be done as early as possible, preferably within 7 days to provide the most useful information. Sizeable focus of bleed (>1 cm) was found to be significantly associated with poor prognosis. By MRI we can evaluate most of the patients of spinal trauma & can correlate various cord findings with clinical findings at the time of trauma.

Keyword-Acute spinal trauma, Neurological status, MRI, Clinical out come

Introduction:

Magnetic Resonance imaging (MRI) is a non-invasive imaging technique that does not involve exposure to ionizing radiation. It uses a strong magnetic field, radiofrequency pulses and a computer to produce a detailed picture of organs including all soft tissue structures and bones. MRI plays a crucial role in evaluating and detecting spinal injuries **[1-5]**.Subtle bone marrow, soft tissue and spinal cord abnormalities which may not be apparent on other imaging modalities can be readily detected on MRI. It is especially helpful for diagnosing or ruling out acute compression of the spinal

cord. MRI permits direct visualization of the morphology of the injured cord parenchyma and relationship of the cord with surrounding structures. No other imaging modality has been able to consistently reproduce internal architecture of the spinal cord **[6-8]**. In India most common mode of spinal injury is fall from height **[9]**. Road traffic accidents are the second most common mode of injury and are on the increase. Early detection helps in prompt accurate diagnosis and expeditious management in many cases avoiding unnecessary procedures. Various previous studies have been carried out to correlate MRI findings with neurological deficit**[10-16]**.This study was carried out to evaluate cases of spinal trauma by MRI and to correlate with clinical findings according to ASIA impairment scale.Assessment of predictive factors for adverse neurological outcome were also carried out.

Aims and Objectives:

1-To evaluate the role of MRI as a non-invasive diagnostic tool in cases of spinal trauma.

2-To correlate MRI findings with patients' clinical profile according to ASIA impairment scale.

3-To determine whether any MRI findings at presentation are able to predict poor clinical outcome.

Materials and Methods:

This study was conducted in a tertiary care hospital. One hundred twenty four patients of spinal trauma were included in the study.

Inclusion criteria: Patients of spinal trauma with or without neurological deficit at presentation.

Exclusion Criteria: Poly trauma patients or those with contraindications to MRI examination (patients with pace maker, metallic implant, cochlear implants in situ or uncooperative patients)

Detailed history with respect to age, sex, mode of injury and date of injury was taken from all patients. Prior to imaging, a standardised physical examination was carried out. We utilized the American Spinal Injury Association 2000 (ASIA) standards for clinical evaluation.

Categories of the ASIA Impairment Scale

A: Complete: No motor or sensory function is preserved in the sacral segments S4-S5.

B: Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.

C: Incomplete: Motor function is preserved below the neurological level, and more than half of the key muscles below the neurological level have a muscle grade of less than 3.

D: Incomplete: Motor function is preserved below the neurological level, and at least half of the key muscles below the neurological level have a muscle grade of 3 or more.

E: Normal: Motor and sensory function are normal.

MRI Techniques in Spinal Trauma

All patients underwent MR imaging within one week of injury. A 1.5T magnet was used for the examination. MRI of injured spine was performed in axial, sagittal and coronal planes using a combination of pulse sequences. Imaging was performed with patient in supine position and during quite breathing. Sagittal T2 and T1 weighted fast spin echo (FSE) images, STIR & fat suppression images were acquired.Coronal STIR and Axial T2 & T1 weighted fast spin echo images were also acquired.Gradient recalled echo (GRE) images were taken for proper evaluation of cord haemorrhage. Both T1 and T2 weighed FSE images are necessary to completely assess the spinal axis and spinal cord.

Results:

Table I A- Profile of spinal trauma patient.

	Group	**No.**	**%**
Sex	Male	88	70.9

	Female	36	29.1
Age (yr)	0-20	24	19.3
	21-40	80	64.5
	41-60	20	15.6
Cause	Fall from height	76	61.3
	RTA	28	22.6
	Fall of weight	14	11.3
	Other	6	4.8

Amongst the study group 70.9% cases were male. 64.5% cases were in 21-40 year age group. Fall from height (61.3%) constituted the most common cause of spinal injury (table I).

Table IB- Profile of patient of spinal trauma patient.

	Group	**No.**	**%**
Vertebral involvement	Single wedge compression/collapse	100	80.6
	Secondary wedge compression/collapse	24	19.4
Site of Injury	Dorso Lumbar D12-L1	56	37
	C5-C6	24	19.4
	D7	12	9.7
	Others	42	33.8
ASIA impairment Scale	A	52	41.9
	B	2	1.6
	C	12	9.7
	D	34	27.4
	E	24	19.4

In respect of vertebral involvement, in 80.6% cases single wedge compression/ collapse were found. Most common site of injury was Dorso lumbar D12-L1 (37%) followed by C5-C6 (19.4%). At presentation maximum number of patients belonged to ASIA A (41.9%) followed by ASIA D (27.4%). (Table-IB)

Table II-Cord abnormality on MRI of trauma patient

Cord Abnormality	**No of Patients**
Sizable focus of haemorrhage	40/124 (32.3%)
Cord Oedema/Contusion(<3cm)	28/124(22.6%)
Cord oedema/Contusion (>3cm)	56/124 (45.2%)
No Finding in cord	30/124 (24.2%)

In our study we found out that cord abnormalities were present in 94 out of 124 patients i.e. 75.80% of patients. In 30/124 i.e. 26.32% of patients no abnormality was noted in cord.Sizable focus of haemorrhage (> 1cm) involving cord were present in 40 / 124 patients i.e. 32% of patients (Fig1). In 84/124 patients i.e. 68% no significant haemorrhage was seen (Fig2). Cord oedema / non haemorrhagic contusion involving less that 3 cm cord was present in 28 /124 patients i.e. 22.6%(Fig.3).Cord oedema/contusion involving more than 3 cm of cord was present in 56/124 patients i.e. 45.2%. (fig.4) So cord oedema / contusion involving more than 3 cm of cord was most common cord finding in our study. (Table IIB)

Table III- Outcome in patient of spinal trauma according to ASIA impairment scale at admission (n-124)

AIS	Improvement	Non Improvement	Mortality	Not Applicable	Total number of cases.
A	12	38	2		52
B	2				2
C	8	4			12
D	16	16	2		34
E	-			24	24
Total	38	58	4	24	124

Out of 52 patients with initial AIS A only 12 i.e.23% showed improvement while out of 34 patients with initial AIS D, 16 i.e. 47% patients showed improvement. In patients with initial AIS C, 8/12 i.e. 66% patients showed

improvement So it suggests that chances of improvement are less in patients with initial high grade AIS. (Table3)

Table IV- Multiple logistic regressions for estimating prognosis of spinal trauma patient

Outcome 0Improved, 1 Not improved	**Odds Ratio (95% Confidence Limit)**	**p value**
Cord compression 0 Absent 1 Present	4.22 (0.59, 31.50)	0.149
Sizeable focus of bleed 0 <1 cm, 1 >1 cm	6.63 (1.17, 38.63)	0.032
Cord edema 0 Absent 1 Present	0.26 (0.33, 1.87)	0.178

Multivariate analysis was done to see the effect of various risk factors studied on the outcome of trauma patients. The results of multiple logistic regression that over and above all the risk factors only sizeable focus of bleed (>1 cm) was significantly associated with poor prognosis (OR 6.63; 95% CL 1.2, 38.6; p=0.032).(Table IV, Fig.1)

Discussion:

In all earlier Indian series for e.g**. Chacko et al[17]** ratio-13.5:1, **Shanmugasundram[18]** ratio- 8.98: 1&**Roop Singh et al[9]** ratio-2.96 : 1, sex distribution showed higher number of male in comparison to female. In our study the ratio was 2.44:1, it is reflecting a change in trend when compared to studies conducted 15 to 20 years back (Table IA). There has been substantial decrease in male to female ratio reflecting changing face of social norms. In our study mean age was found to be 31.2 yr. (Table IA) In a similar study carried out by **RoopSinghet al[9]**the median average age at injury was 35.4 years. Falls were more prominent in second and third decades.In our study the most common mode of trauma was fall from height.Second most common cause was Road Traffic Accidents (RTA) (table IA). In a study carried out in India by **Roop Singh et al[9]**similar results were obtained, they shown that the most common cause of injury was fall from height.In advanced countries RTA ranks highest. **Shingu et al [19]** in Japan showed that RTA accounts for 44.6% and fall from height was 29.2% as a mode of trauma.Most common site of injury was Dorso lumbar D12-L1 (37%) followed by C5-C6 (19.4%).(Table IB) In a similar study **Roop Singh et al [9]**showed that the Dorsolumbar spine injury was the commonest with first lumbar being the most common fractured vertebra followed by twelfth dorsal vertebra, cervical spine injury was next with most common site being fifth and sixth cervical vertebrae. In our study secondary injury level was seen in 24/124 i.e. in 19% of cases(table IB). In a similar study **Green RA et al [20]** demonstrated secondary injury in 77% of cases. This discrepancy may be due to different modes of trauma in developed & developing countries. The most common finding which was invariably present in our study was bone marrow oedema In most of the patients wedge collapse was seen (Table II). (.In our study we found out that cord abnormalities were present in 94 out of 124 patients i.e. 75.80% of patients. In 30/124 i.e. 26.32% of patients no abnormality was noted in cord.(Table II) In a similar study by **Kulkarni et al[21]**cord abnormalities were present in 70% of Patients while skeletal abnormalities were present in 78% of patients. Sizable focus of haemorrhage (>1cm) involving cord was present in 40/124 patients (32%). Cord oedema/ non haemorrhagic contusion involving less than 3cm cord was present in 28/124 patients (23%). Cord oedema /contusion involving more than 3 cm of cord was present in 28/62 patients (45%). So cord oedema/ contusion involving more than 3 cm of cord were most common cord finding in our study. (Table II)

In patients with sizable focus of haemorrhage in cord (>1cm), initial paralysis was graded as AIS A in 38 out of 40 patients and AIS B in one patient.In our study, sizeable

focus of bleed (>1 cm) was significantly associated with poor prognosis (OR 6.63; 95% CL 1.2, 38.6; p=0.032)(TableIV,Fig.1.) In a similar study **Boldin et al[22]** showed the effect of haemorrhage and length of hematoma on neurological impairment. They showed that patients with haemorrhage were more likely to have complete SCI at the time of follow up (Odds ratio 2.33).In a similar study **Andreoli C[16]** showed that patients with initial haemorrhage have a poor prognosis while oedema has better prognosis.**Flanders et al[23]** showed that patients without spinal cord haemorrhage had significant improvement in self care and mobility scores as compared to patients with haemorrhage. **Flanders et al[23]**also showed similar results as our study. They demonstrated that presence of haemorrhage was a bad prognostic indicator. Patient with haemorrhage have lower motor scores with poor recovery (p<0.001).**Selden NR[24]** showed that presence of severe cord compression by vertebral or extra axial hematoma are associated with poor neurological function at presentation and follow up.

Conclusions:

From our study we conclude that MRI should be done as early as possible, preferably within 7 days to provide the most useful information. Sizeable focus of bleed (>1 cm) was found to be significantly associated with poor prognosis. T2 FSE sagittal images are the best images for the evaluation of spinal trauma. For evaluation of cord haemorrhage, best images were gradient recalled echo (GRE) images. So MRI is an excellent diagnostic modality for evaluation of spinal trauma. By MRI we can evaluate most of the patients of spinal trauma & can correlate various cord findings with clinical findings at the time of trauma. Presence of intra cord haemorrhage indicating poor prognosis can be identified.

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Fig. 1- T2W sagittal MR image of 18yrs old male patient presented with history of fall from height two days prior to the MRI. MR examination reveal grade 3 spondylolisthesis of D12 over L1 with fracture dislocation of facet joints at the level D12/L1 with severe cord compression, cord contusion and cord hemorrhage. On clinical examination the initial AIS was A, after treatment and follow up no improvement was seen. Thus involvement of long segment of cord, sizable focus of cord hemorrhage and severe cord compression were bad prognostic indicators.

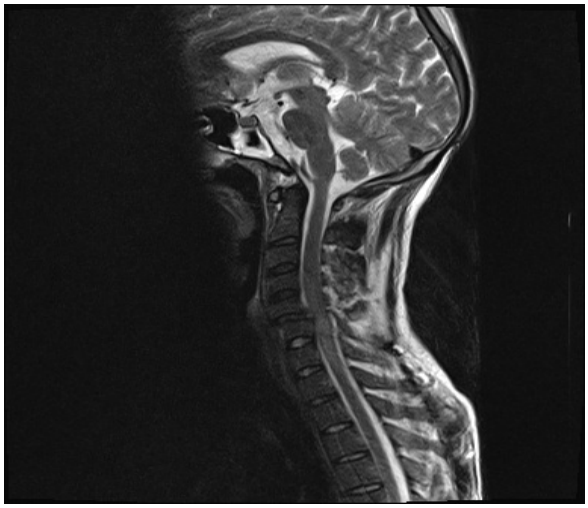

Fig. 2- 35 yrs female with history of fall from height 5days prior to MRI. Sagittal T2W MR imaging reveals partial wedge collapse of C5 vertebra with grade 2 spondylolisthesis at C5-6 level with prevertebral hematoma and cord contusion/edema extending from cervicomedullary junction to C8 vertebral level with small focus of hemorrhage. On clinical exam at admission the AIS was A, patient was followed till discharge. The AIS at discharge was D s/o improvement. Small hemorrhage <1cm was good prognostic indicator for the recovery of the patient

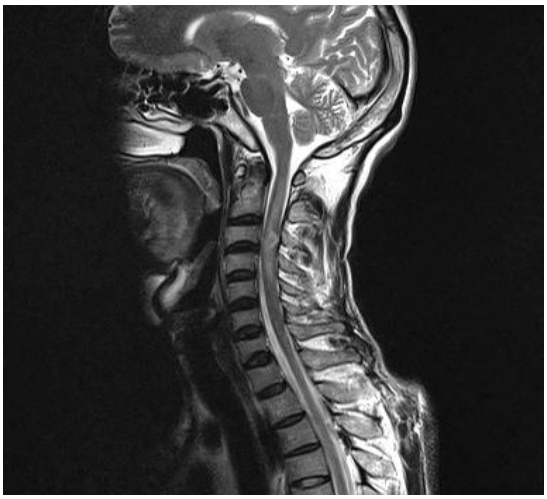

Fig3- Alleged history of fall from height 4 days prior MRI. Sagittal T2W MR imaging reveals grade 1 spondylolisthesis at C5-C6 with mild cord compression and small cord edema/ contusion. On clinical exam at admission the AIS was C, patient was followed till discharge. The AIS at discharge was D s/o improvement. Absence of hemorrhage was good prognostic indicator for the recovery of the patient.