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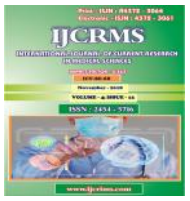

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Role of Magnetic Resonance Imaging in diagnostic evaluation of Spinal Trauma

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Abstract

A prospective cross sectional study was undertaken in the department of Radiodiagnosis, GMC Amritsar over a period of two years, to assess the use of MRI as a diagnostic tool in evaluation of spinal trauma.

It aimed at studying characteristic imaging findings, to establish a differential diagnosis of various traumatic lesions and to evaluate role of MRI in patients of spinal trauma. All patients with history of spinal trauma were subjected to MRI examination. Out of these 50 patients were chosen randomly, for analysis. Findings were tabulated and inferences drawn. The peak age range for spinal trauma was 19 to 40 years with male to female ratio of 4.5:1. Most common chief complaint was pain in the spinal region. Major cause for spinal trauma were vehicular accidents and fall form height. Level of injury was maximally seen in cervical spine (36%) followed by thoraco-lumbar region (32%). Vertebral body injury (40%) was maximally seen in thoracolumbar junction (60% cases). Reduction of disc space was present in 6(12%) cases and disc edemain 4(8%) cases. 8(16%) cases showed posterior longitudinal ligament disruption and 8(6%) cases revealed disruption of both anterior as well as posterior longitudinal ligament. Cord edema/contusion was present in 11(22%) cases.

The study concluded that MRI is of great value in evaluating the acutely injured spine, and contributes to assessment of vertebral injury, ligamentous disruption, associated disc protrusion as well as the exact site of maximal canal stenosis and nature of the cord injury. MRI imaging leads to prompt and accurate diagnosis, expeditious management, and avoidance of unnecessary procedures, thus, improving posttraumatic quality of life.

Keywords: MRI, Spine, Trauma

Introduction

MRI has been playing an important role in the management of spinal trauma patients. It is the modality of choice for evaluation of ligament and other soft tissue structures. Injuries of discs, spinal cord and occult osseous injuries are very well seen with MRI. Quick and proper management of the patients from diagnosis to therapy implies reduction of neurological damage, thus, improving quality of life for posttraumatic patients. Radiologists have a role of great responsibility in establishing the presence or absence of lesions, defining the MRI characteristics, assessing the prognostic value and therefore deciding the treatment.

The typical MRI protocol for spinal injury includes sagittal T1 weighted (T1W) and T2 weighted (T2W) spin echo sequences, and T2* weighted (T2*W) gradient recalled echo (GRE) sequence, and sagittal short tau inversion recovery (STIR) sequences, as well as axial T2W and T2*W GRE sequences. T1W images are mainly used for depiction of anatomy and osseous fractures. STIR images are very sensitive for detection of edema and are helpful in diagnosing the soft tissue and ligamentous injuries, particularly of the interspinous or supraspinous ligaments. Although fat-suppressed T2W images can also be used for detection of edema, STIR images provide more uniform fat suppression. T2W images are very good in detecting the cord edema, and T2*W GRE images are used to detect the hemorrhage in and around the cord.

Normal anatomy

The adult vertebral column normally consists of 33 vertebra, but only 24 of them (7 cervical, 12 thoracic and 5 lumbar vertebrae) are mobile. The five sacral vertebrae are fused to form the sacrum and the four coccygeal vertebrae are fused to form the coccyx. The vertebral column is stabilized by ligaments which somewhat limit the movements produced by the back muscles. Additional stability is provided by muscles, intervertebral discs, and the shape of the vertebrae. The spinal cord and the spinal nerve roots are located within the vertebral canal.

The intervertebral discs are interposed between adjacent vertebral bodies and hydrostatically cushion the mechanical forces present.

The vertebral bodies and intervertebral discs are linked together by a variety of ligaments. Spinal ligaments are very important to maintain the normal alignment between vertebral segments under a physiological load. The three major ligaments of the spine are the ligamentumflavum, anterior longitudinal ligament (ALL) and posterior longitudinal ligament (PLL).

Normal ligaments of the spine appear as low signal intensity bands on all the sequences.[1]

The spinal cord begins as the caudal extension of the medulla oblongata at the level of the foramen magnum. On MR images, the spinal cord has intermediate signal on T1-weighted sequences and low signal on T2-weighted and gradient-echo sequences.[2]

Three-column concept of spinal stability

Based on biomechanical studies, the vertebral column can be divided into three vertical parallel columns (i.e. anterior, middle and posterior columns) according to the Denis classification for the purposes of evaluating stability.[3]Spinal injury is usually classified as unstable when two contiguous columns are affected.

Ligamentous injury

Ligamentous injury appears as focal disruption of the hypointense signal on all the sequences with associated prevertebral edema best identified on STIR images.[4]

In a prospective analysis of MR imaging accuracy in the diagnosis of traumatic PLC(posterior ligamentous complex) injuries, it was found to have overall sensitivity and specificity of 91% and 100% respectively, with 100% accuracy in diagnosis of surgical fractures.[5]

Since ligaments are essential components of spinal columns, the presence of their injury can change a single column injury to a two column injury, thus upgrading a stable injury to an unstable injury.

Acute traumatic disc herniation

Traumatic disc herniations are most commonly associated with vertebral fracture dislocations and hyperextension injuries of the spine, and are caused by injuries to annulus fibrosus with nucleus pulposus herniation.

Extra medullary hemorrhage and fluid collections

Extradural hematoma is the most common type of extra medullary collections in trauma patients. Subdural hematoma and subarachnoid hemorrhage are uncommon. Pseudomeningoceles

and extradural fluid collections due to dural tear are other uncommon sequelae of spinal trauma. Epidural hematomas usually appear isointense to slightly hyperintense on T1W images and hyperintense on T2W images. Entire craniocaudal extent of the hematoma can be easily evaluated on sagittal MRI. Similar to epidural hematomas, subdural hematoma and subarachnoid hemorrhage show collections with varying signal intensities in the subdural and subarachnoid spaces, respectively.[6,7]

Vascular injuries

Vascular injuries can be caused by both blunt and penetrating trauma. Most of the vascular injuries can be seen as irregularity or loss of normal flow void on long TE sequences such as T2W images. Fat-suppressed T1W images are better to identify the high signal intensity intramural hematoma associated with dissection. In equivocal cases, CT angiography or catheter angiography can be used for further evaluation of vascular injuries.[8]

Spinal cord injuries

Most common MRI findings of cord trauma include abnormal hyperintense T2 signal suggesting cord edema, hypointense signal depicting hemorrhage which is best seen on GRE images, and a mixture of edema and hemorrhage.[9]

Other osseous and soft tissue injuries

Osseous injuries with little apparent morphologic changes such as compression and cortical break are difficult to be diagnosed with CT. MRI is very sensitive for detection of these occult osseous injuries by showing marrow edema and hemorrhage as hyperintense signal on fluid-sensitive sequences such as STIR.[10]

Aims and Objectives

The objectives of this study are to:

1. To study the characteristic MR imaging findings in various traumatic lesions of spine.
2. To establish a differential diagnosis of the various traumatic lesions on MRI.
3. To evaluate the role of MRI as a non-invasive diagnostic tool in patients with acute spinal trauma.

Materials and Methods

This cross-sectional study was conducted in the Department of Radio diagnosis, Government Medical College, Amritsar. The study was conducted after approval from institutional thesis and ethical committee.

All patients who underwent MRI of spine with history of trauma in the Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar were subjected for this study. In all the cases, written informed consent was taken from patients or his/ her attendants before conducting the study. Out of these, 50 cases were selected randomly.

Examination technique and scanning protocols:

MRI was done on SIEMENS MAGNETOM AERA 1.5 TESLA machine.

Appropriate MR sequences and multiplanar imaging was performed for every patient using following sequences.

- Localizer conventional spin echo sequence
- Axial and sagittal T1W sequence
- Axial, sagittal and coronal T2W sequence
- Sagittal-STIR T1W FS(fat saturated) sequence
- Coronal-TIRM(turbo inversion recovery magnitude) T2W sequence
- Susceptibility weighted imaging sequence

Inclusion criteria:

The patients undergoing MRI of spine for various traumatic etiologies in the Department of Radiodiagnosis and Imaging, Govt. Medical College, Amritsar.

Exclusion criteria:

- The study excluded patients having history of claustrophobia.
- Patients who had metallic implant insertion, cardiac pacemakers and metallic foreign body in situ.
- Cases where scanning was not possible due to poor general conditions of the patients and where MRI was contraindicated.

Data Analysis: Proportion study.

Observations and Results

Table I Age wise distribution of cases (n=50)

Age (years)	No. of cases	Percentage %
0-18 years	03	6.0
19-30 years	14	28.0
31-40 years	15	30.0
41-50 years	07	14.0
51-60 years	05	10.0
>60 years	06	12.0
Total	50	100

Table I: In our study which consisted of 50 cases, the age range of patients was from 8 years to 89 years and the peak range of age distribution was between 19 to 40 years i.e. 58% of all cases.

Table II Sex wise distribution of cases (n=50)

Sex	No. of cases	% age
Male	41	82.0
Female	9	18.0
Total	50	100.0

Table II: Out of 50 cases, 41 were male and 9 were female with a male to female ratio of 4.5:1.

Table III Mode of trauma (n=50)

Mode of trauma	No. of cases	% age
Accident	29	58.0
Fall from height	12	24.0
Assault	5	10.0
Others	4	8.0
Total	50	100.0

Table III: It was found that vehicular accidents were the most common cause of spine related injury in 29(58%) cases, followed by fall from height in 12(24%) cases and assault in 5(10%) cases.

Table IV Level of injury in patients with history of spinal trauma (n=50)

Location	No. of cases	% age
C1-C7	18	36.0
T1-T6	1	2.0
T7-T10	8	16.0
T11-L2	16	32.0
L3-L5	3	6.0
Sacral spine	2	4.0
>1 Level	2	4.0
Total	50	100.0

Table IV: The most common level was found to be to cervical spine in 18(36%) cases, followed by thoraco-lumbar region in 16(32%) cases, mid-thoracic spine in 8(16%) cases and lower lumbar spine in 3(6%) cases. Only two cases were seen affecting the spine at more than 1 level and affecting the sacral spine.

Table V Osseous findings on MRI

Osseous findings	Location							Total	
	C1-C7	T1-T6	T7-T10	T11-L2	L3-L5	Sacral	>1 segments		
	No.	No.	No.	No.	No.	No.	No.	No.	%
Vertebral body	2	-	4	12	2	-	-	20	40.0
Posterior elements	2	-	-	-	-	-	-	2	4.0
Subluxation/Dislocation	1	-	2	-	-	-	-	3	6.0
Vertebral body + Others	-	-	2	2	-	-	-	4	8.0
Others	4	-	-	2	-	2	-	8	16.0
No Finding	9	1	-	1	1	-	1	13	26.0

Table V: It was found that vertebral body injury was seen in 20 (40%) cases, with maximum cases being in the thoracolumbar junction (60%).

Table VI Findings in spinal ligaments on MRI (n=50)

Findings	No.	%age
ALL	3	6.0
PLL	8	16.0
Ligamentumflavum/supraspinous /interspinous ligament/posterior ligamentous complex	1	2.0
ALL+PLL	8	16.0
ALL+PLL+ Ligamentumflavum/supraspinous/interspinous ligament/posterior ligamentous complex	4	8.0
PLL+ Ligamentumflavum/supraspinous/interspinous ligament/posterior ligamentous complex	1	2.0
No finding	25	50.0

Table VI: It was found that the most common ligament to be injured was PLL with both ALL-PLL seen in 8(16%) cases.

Table VII Findings in cord on MRI in spinal trauma (n=50)

MRI Findings in spinal cord	No.	%
Cord edema/contusion	11	22.0
Cord compression	4	8.0
Cord edema/contusion+Cord compression	9	18.0
Cord haemorrhage	2	4.0
Cord transection	2	4.0
No finding	22	44.0

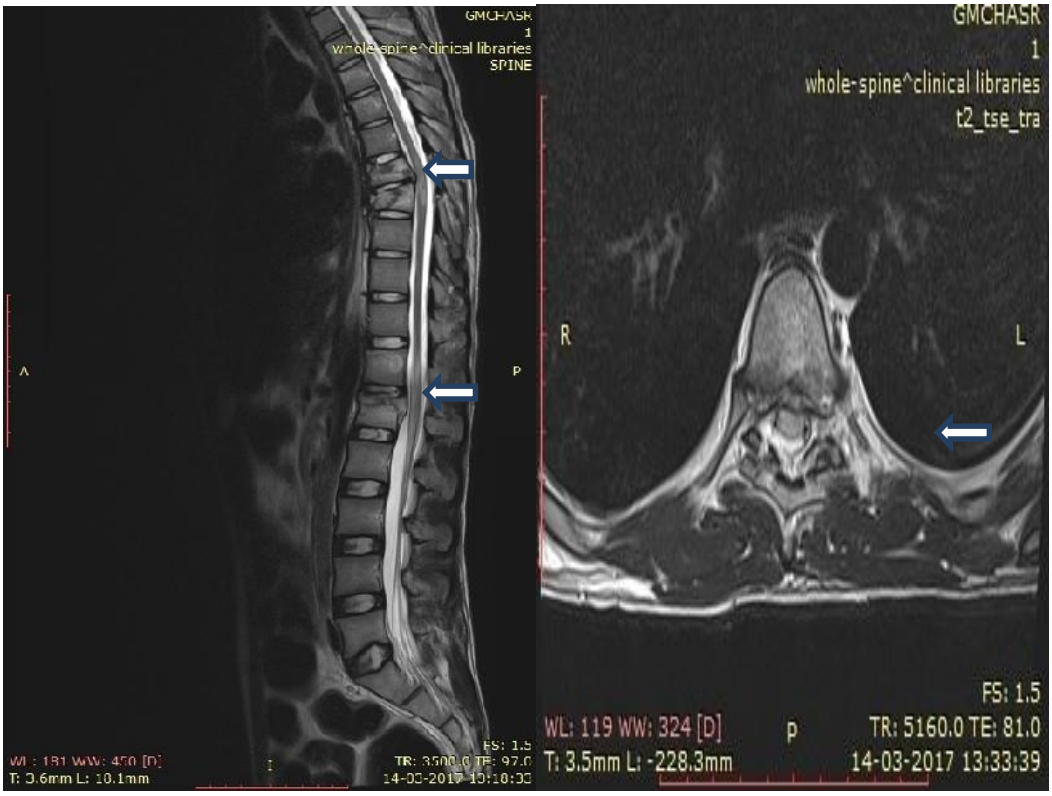
Table VII: It was found that cord edema/contusion was seen in 11 (22%) cases, followed by a combination of cord edema/contusion and cord compression in 9 (18%) cases and only cord compression in 4(8%) cases. The least common finding was cord haemorrhage and cord transection which was seen only in 2(4%) cases respectively.

Cases

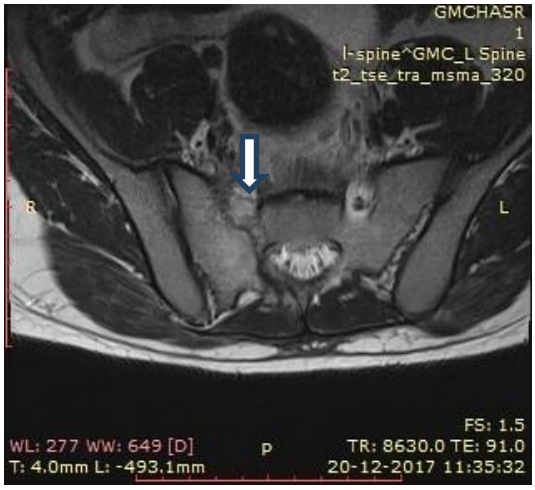
Sagittal T2W image of a 40 year old female with history of vehicular accident shows wedge compression fracture of T11 with hyperintense signal seen on T2WI in vertebral body of T10 and T11.There is disruption of ALL and PLL. Cord edema is seen at level of T10-T11. An anterior epidural collection is also seen at this level causing spinal canal stenosis.

Sagittal T2- STIR image of a 27 year old male shows complete anterior dislocation of C5 over C6 with complete cord transection. ALL, PLL as well as the posterior ligamentous complex is disrupted. Hyperintense signal s/o edema is seen in the paraspinal soft tissues at this level.

Saggital T2-STIR and SWI images of a 26 year old male with complaint of quadriplegia show an ovoid focus of hypointensity on T2-STIR image which shows blooming on SWI s/o cord haemorrhage. Cord edema is also seen from C2 to C5 level.



Saggital T2W and Axial T2W images of a 18 year old male show spinal cord injury at more than 2 levels. A wedge compression fracture of T6 and T7 is seen with IV disc space reduction at T6-T7 and spinal cord edema at this level. Fracture of the vertebral body of L1 is seen with PLL disruption at this level.



Saggital T2W image of a 35 year old male with complaint of bowel/bladder incontinence shows fracture through the right sacral ala and neural foramina.

Discussion

In this study, the age range of patients was found from 8 years to 89 years and the peak range of age distribution was found between 19-40 yrs of age i.e. 58% of all cases. These findings were comparable with the findings of Gupta R. et al and Hassan Gamal G. where with mean age groups were 43 years and 41.2 years respectively.[11,12]

Out of 50 patients, the study sample consisted of 41 males and 9 females with male to female ratio of 4.5:1.These findings correlate well with the similar studies done by, Hassan Gamal G., Gupta R. et al,Debebe F. et aland Lalwani S. et al.[11,12,13,14]

The relative predominance of young male patients is most likely due to increased mobility, work related injuries and road traffic accidents

In our study, vehicular accidents accounted for injuries in 58% of cases, followed by fall from height in 24% of cases and assault in 10% of cases.These findings were consistent with the findings of Hassan Gamal G. where the main causative agents of spinal injury were motor vehicle accidents (41.8%), falls from height (28.6%), motorcycle accidents (19.4%), sports (6.1%), and others (4.1%).[11] Similar results were also obtained in the studies conducted by Debebe F. et al,Rahimi-Movaghar V. et al and Tee J. et al.[13,15,16]

In our study, it was found that in males the predominant cause of injury was vehicular accidents (63.4%), followed by fall from height (14.6%) and in females; it was fall from height (66.6%) followed by accidents (33.3%).

In our study, the main presenting complaint for which the patients were referred for MRI of spine was found to be pain over the injured area of the spine in 48% of the cases. The most common neurological deficit was paraplegia/paraparesis in 20% of the cases, followed by quadriplegia/ quadriparesis in 18 % of cases with Bladder/bowel dysfunction seen only in two (4%)casescorrelating with a study done in USA which showed that out of 250,000 Americans who had spinal cord injury; 52% were considered paraplegic and 47% quadriplegic.[17] Studydone by Razzak A. et al alsofound that 70.5% of the injury resulted in paraplegia and 29.5% in tetraplegia.[18] The clinical presentation of SCI in Flanders et al study was incomplete quadriplegia (29.5%), complete paraplegia (27.9%), incomplete paraplegia (21.3%) and complete quadriplegia (18.5%) with less than 1% of patients recovering completely during the initial hospitalization.[19]

The most common level of injury in our study was found to be cervical spine in 36% cases followed by thoraco-lumbar region in 32% of cases. These findings are consistent with studies conducted byGupta R. et al.,Debebe F. et al, Lalwani S. et al., Aswani Kumar K. et al.[100,105,107,113]Studies done in China and Pakistan also reported the highest rate of cervical injury (71.5 and 68%, respectively).[20,21]

Our study found that vertebral body injury was seen in 20 (40%) cases with maximum cases being in the thoracolumbar junction in 12(60%) cases. These results are similar to a study conducted in India in 2007, in which it was found that out of all the spinal fractures, 90% occured between T-11 and L-4 vertebra.[22]

In our study no ligamentous injury was seen in 50% of cases followed by PLL disruption (16%) and both ALL-PLL disruption (16%).Geck M. et al, found that out of the total 89 patients, 82 had no ligamentous injury, and 7 had ligamentous injury.[23]

In our study, the most common finding in spinal cord was spinal cord edema in 11(22%) cases. Bleeding or hemorrhage in the spinal cord was seen in 2(4%) cases and cord transaction was also seen but only in 2(4%) cases.

In the study conducted by Gupta R. et al, the most commonly observed MRI pattern was pattern II (edema) seen in 26% of the subjects. Pattern III (contusion) was observed in 24% of subjects and Pattern I (haemorrhage) was observed in 16% of the subjects. Pattern IV (6%) and pattern V (4%) were least commonly observed.[12]

Parashari et al, in 2011 found that out of 62 patients with SCI there was spinal cord edema without hemorrhage in 41.5% and areas of bleeding in the spinal cord in 33%, epidural hematoma in 5% and normal spinal cord was seen in 26%. Patients with spinal cord edema and hemorrhage areas had more neurological damage and poor prognosis.[24]

So all these studies as well as our study have reported the higher incidence of edema in patients with acute SCI.

In our study, epidural haematoma/collection was seen in 8% of cases. Parashari et al, also found that epidural hematoma was present in 3 patients (4.84%) with history of spinal trauma.[24]

Conclusion

The trauma patients who were referred for magnetic resonance imaging of the spine were evaluated with an aim to ascertain injuries in the vertebral column, spinal cord and the paraspinal ligamentous complex, through MR pulse sequence characteristics. The most common causes for spinal trauma include fall from height, blunt trauma and vehicular accidents respectively. Most trauma cases occurred in middle age group with a male predominance. The categorization of spinal trauma into acute and chronic is arbitrary. The most common sites of spinal trauma are mid cervical and thoracolumbar junctions. The greatest advantage of MR imaging is its ability to identify disc, cord, ligament and soft tissue injuries in addition to fracture localization and charecterisation which are of greatest prognostic significance. The main disadvantage of MR imaging is suboptimal evaluation of posterior element fractures and incompatability in patients with pacemakers and ferromagnetic implants. Despite these disadvantages, MR imaging leads to prompt and accurate diagnosis, expeditious management and avoidance of unnecessary procedures, thus, in the process, improving post traumatic quality of life of patients of spinal trauma.

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