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Spinal Trauma Evaluation by MRI—Research Article

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I. Introduction

The radiologist has a pivotal role in evaluation of 'spinal trauma' with objective to eliminate the possibility of further damage and to identify the lesions which can be corrected, and to evaluate the prognosis .

The imaging evaluation of spinal cord injury (SCI) has undergone a remarkable evolution with the development of Magnetic Resonance Imaging. Although plain radiographs, myelographyand computed tomography were once the mainstay of spinal imaging, the MRI has recently become a necessity in the management of SCI. The vertebral column, spinal cord, and adjacent soft tissue structures and neural compression can directly be imaged by MRI. The information provided by MR imaging has radically changed our abilities to access the patient in the emergent period and has altered our understanding of pathophysiology of SCI and its prognosis.

With this background, the present study is aimed to review the magnetic resonance characteristics in prospective evaluation of SCI, and to assess the potential impact of MR imaging in the management of spinal axis trauma.

II. Aims And Objectives

Of the present study are to evaluate the common modes and site of injury in spinal trauma, to evaluate the injury to the spinal cord (edema, hemorrhage, compression and transection of cord), to identify ligamentous disruption, IV disc involvement, paraspinal soft tissue abnormalities and osseous injury in case of trauma.

III. Material And Methods

This was a prospective study comprised of 60 patients who sustained ‘trauma of spine’ and underwent ‘MagneticResonance Imaging’ during March 2013 to March 2015 in the department of Radiodiagnosis, Andhra Medical college, Visakhapatnam.

All patients presenting with history of trauma to spine to orthopedics and neurosurgery departments were included in the study. The subjects belonged to both genders between 10 to 80 years of age. Patients who were medically unstable, patients with cardiac pacemakers, ferromagnetic aneurysm clips, other ferromagnetic implants (Ex: cochlear implants), intraocular metallic foreign bodies and Patients with claustrophobia were excluded from the study.

The MRI scanner used was GE 1.5 Tesla. In all cases, the clinical records (nature of spinal injury and neurologic status) and concerned plain radiographs of spine were received before MRI. In all cases T1 weighted, T2 weighted, Gradient-echo and STIR sequences were obtained in axial, sagittal and coronal planes. Also the time gap between trauma and MRI study was noted for correlating the imaging appearances of acute and chronic spinal injury. Each examination was assessed with respect to extraspinal soft tissues, the vertebral column including intervertebral discs and the intraspinal contents such as cord and thecal sac.

The patients with potentially unstable injuries of spine or those requiring traction were carefully transferred to the scanning cradle of MRI equipment, under medical supervision. Sedation was required in few patients to contain movement of head and neck, and to obtain optimal signal to noise ratio of MRI study.

IV. Observations

Incidence & Gender Distribution:

The sixty patients included in our study were between 10 to 80 years of age of which the youngest was of 10 years and the oldest was of 80 years . The age distribution revealed maximum (one third) incidence of spinal injury in 3rd decade and the mean age being 26.5 years. Further, the mean age of male patient was 34.8 years, whereas it was 37.3 years for female patients. There were 48 male (80%) and 12 female (20%) patients with male to female ratio of 4:1.

Mechanism Of 'Injury To The Spine

The mechanism of injury was fall from height -30/60 (50%), Blunt trauma 15/60 (25%), Road traffic accidents (13.3), other causes like gun shot wound, fall of bricks etc (11.7%)

Presentation:

At the time of performing MRI,Out of the 60 patients**,** 18 had quadriplegia, 23 had paraplegia and 36 patients had bladder/bowel dysfunction. A total of motor power loss in 24 and both motor and sensory loss in 22 incidences were reported. Signs of radiculopathy developed at insidious phase in 2 patients who sustained lumbar spine injury . No neurologic deficit reported in four patients.

Level Of Injury:

The MR study demonstrated injury to cervical spine (36.7%) most commonly followed by thoraco-lumbar region (33.3%) in the present study. Sacral segment was involved in only one case as a rare occurrence of trauma of spine. Non-contiguous concomitant injury, away from main trauma level, were detected in 6 instances.chart 1(a).

Chart 1

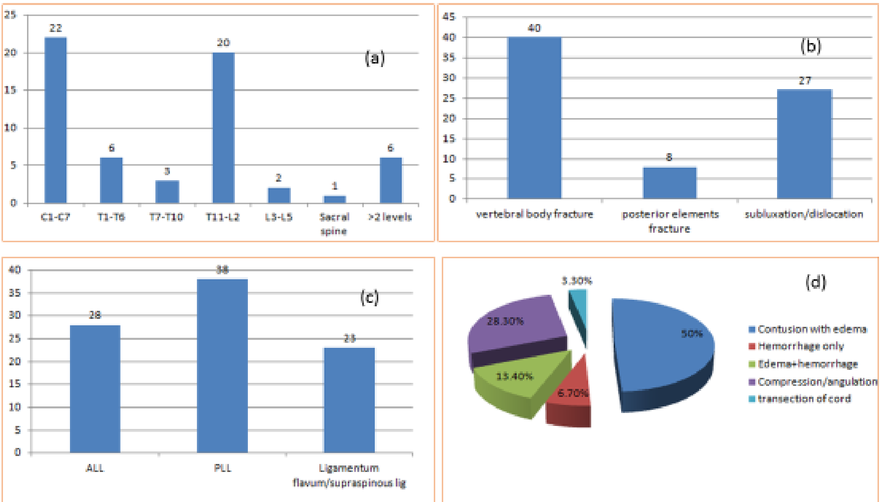

Chart -1(a): Level of Injury.
Chart -1(b): Osseous injury.
Chart -1(c): Disruption of ligaments.
Chart -1(d): Cord Abnormalities.

Table-1 shows the spectrum of general findings over MR images in spinal trauma. The fracture of vertebral bodies demonstrated in 66.7% cases, along with 45% incidence of their subluxation/dislocation. Signs of disc injury including the herniation were present in 43.3% instances. The normal linearity of anterior longitudinal ligament (ALL) was found to be lost in 46.7%, whereas disruption of posterior longitudinal ligament (PLL) was noticed in 63.3% cases.

MR imaging with sagittal T2-FSE showed evidence of spinal cord contusion /edema in 50% of the total examinations. Signal pertaining to edema + hemorrhage were present in 13.4% cases, while intramedullary hemorrhage of the cord could be discerned in 6.7% scans. Compression / angulation of spinal cord due to subluxated vertebrae were noted in 28.3% cases.

Table -1:MRI Features In 60 Spinal Trauma Patients

MR findings	No. of patients	Percentage
Osseous injury		
• Vertebral body fracture	40	66.7
• Posterior elements fracture	8	13.4
• Subluxation / Dislocation	27	45.0
Inter-vertebral disc injury	26	43.3
Disruption of ligaments		
• Anterior longitudinal	28	46.7

• Posterior longitudinal • Ligamentum flavum/supra & Interspinous	38 23	63.3 38.3
Paraspinal soft tissue changes	25	41.7
Spinal cord injury • Contusion with edema • Hemorrhage only • Edema + Hemorrhage • Compression /angulation • Transaction of cord	 30 4 8 17 2	 50.0 6.7 13.4 28.3 3.3

Table 2: MRI Features In 60 Spinal Trauma Patients – In Each Region:

MRI findings Whole spine	No of Pts / %	Cervical spine C1-C7	Dorsal spine T1-T10	Thoraco lumbar spine T11-L3
Osseous Injury				
Vertebral Body #	40 / 66.7%	9	9	25 (11at T12/L1)
Post element #	8 / 13.4%	2	4	8
Subluxation/ dislocation	27 / 45.0%	10	5	4
IVDisc Injury	26 / 43.3%	7	3	9
Disruption of Ligaments				
ALL	28 / 46.7%	10	7	9
PLL	38 / 63.3%	11	8	15 (7 at T12-L1)
Flavum/ Supra/ Interspinous	23 / 38.3%			10
Soft tissue changes	25 / 41.7%	3	6	7
Spinal cord injury				
Contusion/ edema	30 / 50%	8 single 5 multi	5	12 (8 at T12-L1)
Hemorrhoage only	4 / 6.7%			
Hemorrhoage +edema	8 / 13.4%	4 single 7 multi		
Compression/ angulation	17 / 28.3%	2 EDH 15 SAS obl 4 bony fr	2 EDH 6 SAS Obl 1 cord angu	8 cord angu 19 SAS obl (10 at T12-L1) 3 bony fr
Transaction of cord	3 / 0.5%	1	1	1

*EDH: Epidural Hematoma
**SAS Obl : Subarachnoid space obliteration
***Single: Single segment involvement
****Multi: Multi segment involvement

MRI findings of cervical spine Injury:

The prevertebral swelling developed in 3 cases, all having associated vertebral body fracture and the ALL disruption; These were recognized by interruption of the signal void from cortical bone. The disruption of PLL was discernible in 11cases, which was also co-existing with vertebra fracture / subluxation

Disc herniation was appreciated as indentation over the spinal cord focally. Injury to the intervertebral discs was noted predominently at C6-C7 segment, and these showed higher signal intensity on T2-weighted images. Subluxation of injured vertebra was seen distributed at all levels, but with higher incidence at C4/C5 and C5/C6 regions..

MR characteristics of cervical cord contusion/oedema in single segment was evident in 8 cases and greater than one segment in 5 cases better demonstrable on T2 / STIR sequence. Greater than one spinal segment contusion was found predominently at C6-C7. Cord edema with hemorrhoagic component was appreciable in single segment in 4 cases and multiple segments in 7 cases. Multisegment entity was evenly distributed from C3/C4 to C6/C7 region, showing focal increased signal on T1WI or blooming on GRE sequence with a larger area of high intensity on T2- weighted sagittal images.

Anterior subarachnoid space obliteration was noted in15 cases of which 5 instances were noted at C5/C6 level, followed by three each at lower levels . Bony fragment migration from the fracture vertebrae into the canal could be depicted in 4 instances. Traumatic epidural hematoma was recognized in only 2 cases, exhibiting increased signal on T1WI and isointensity on T2WI.

Table 3: Patterns Of MRSignal In The Spinal Cord

	T1- weighted	No. of cases	T2-weighted		No.of cases
Type I	Low signal	7	Low signal		1
Type II	Expanded cord normal signal	4	High signal	<1 spinal segment	9
Type III	Expanded cord normal signal	4	High signal	>1 spinal segment	12

A different pattern of signal emerged in the spinal cord injured as a result of trauma. Table 3 shows high signal intensity at more than one segment in 12 cases, while increased focal hyperintensity was present in 9 cases on T2- weighted images; discrete cord swelling was associated with these cases. Low signal intensity was characterized on T1-weighted sequence over 7 instances.

MR Imaging FindingssIn Thoracic Spine Trauma

In patients with complete paraplegia, the incidence of vertebral body fracture was observed in 9 cases. Posterior element disruption could be appreciated in only 4 instances. The ALL and PLL were found to be discontinued in majority in T1-T6 segment.

Transection of cord was seen in 1 patient of upper (T1-T6) thoracic spinal injury and swelling of cord was appreciated in 5 cases in T1W sagittal images. The traumatic epidural hematoma could be identified in 2 patients. Paraspinal soft tissue edema and hemorrhage was visible in 6 incidences in thoracic spine.

MR Imaging Findings In Trauma Of Thoraco-Lumbar Region

Out of 25 vertebral body fractures, burst/compression fracture of vertebral body was seen in 11 cases at T12-L1 and in 7 cases at L1-L2level. Intervertebral disc herniation was more common at thoraco-lumbar junction and was observed in 9 cases. The facet joint disruption could be appreciated in 4 cases in parasagittal images.

The posterior longitudinal ligament injury was prominent at T12-L1 and L1-L2 levels of thoraco-lumbar spine. Avulsion of anterior longitudinal ligament occurred consistently in lumbar spine region. Posterior extraspinal injuries could be depicted predominantly at L2-L3 segment.

Cord injury was seen as thecal sac deformity and T2 hyperintense signal in cord in 10 cases at TL junction which is associated with angulation of the cord in 5 cases.

Table 4: Proportion Of Magnetic Resonance Abnormalities In Present Study

Region	No. of incidence	Percentage
Extra-spinal	35	58.3
Vertebral column	54	90.0
Intra-spinal	55	90.3

Proportion Of Magnetic Resonance Abnormalities In Present Study:

The extra-spinal soft tissue injuries: prevertebral soft tissue thickening/edema/ hemorrhage and edema /hemorrhage in posterior ligamentous complex could be visualized in 35 (58.3%) cases. The vertebral column abnormalities were detected in 54 (90.0%) instances, in the form of loss of vertebral body contour or alteration of signal intensity in T2W images. Fracture of posterior neural arch were diagnosed with less sensitivity. Intra spinal abnormalities include Cord contusion, edema, hemorrhage, combination of edema + hemorrhage, cord compression, cord angulation and transaction of the cord and epidural hematomas ,which were observed in 55 instances (90.3%) . The intra spinal abnormalities were better appreciable on sagittal images.

Figure 1

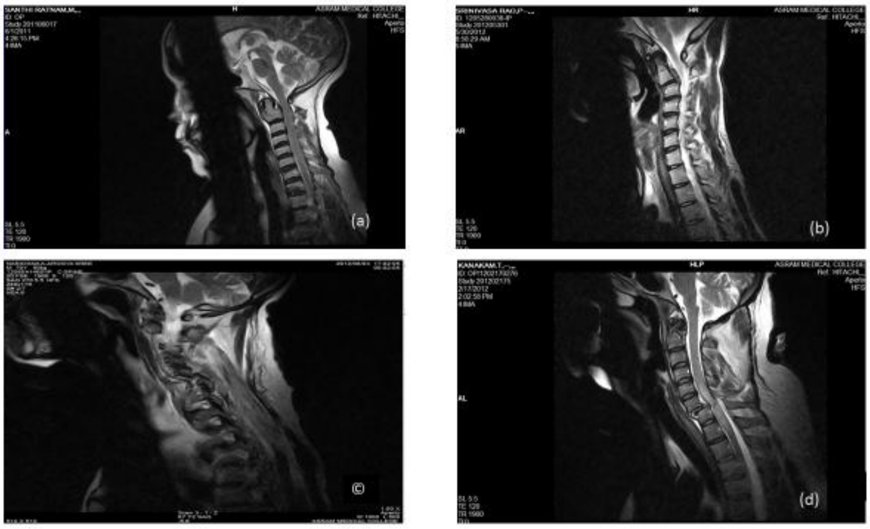

Fig 1(a)-T2-weighted sagittal image of cervical spine showing fracture of odontoid fracture.
Fig 1(b)-T2-weighted sagittal image C-spine shows subluxation of C2 over C3.
Fig 1©-T2-weighted sagittal image of C-spine shows fracture pars interarticularis of C6 vertebra
Fig 1(d)-T2-weighted sagittal image of C-spine showing subluxation of C6 over C7 with suspicious transection of cord at this level.

Figure 2

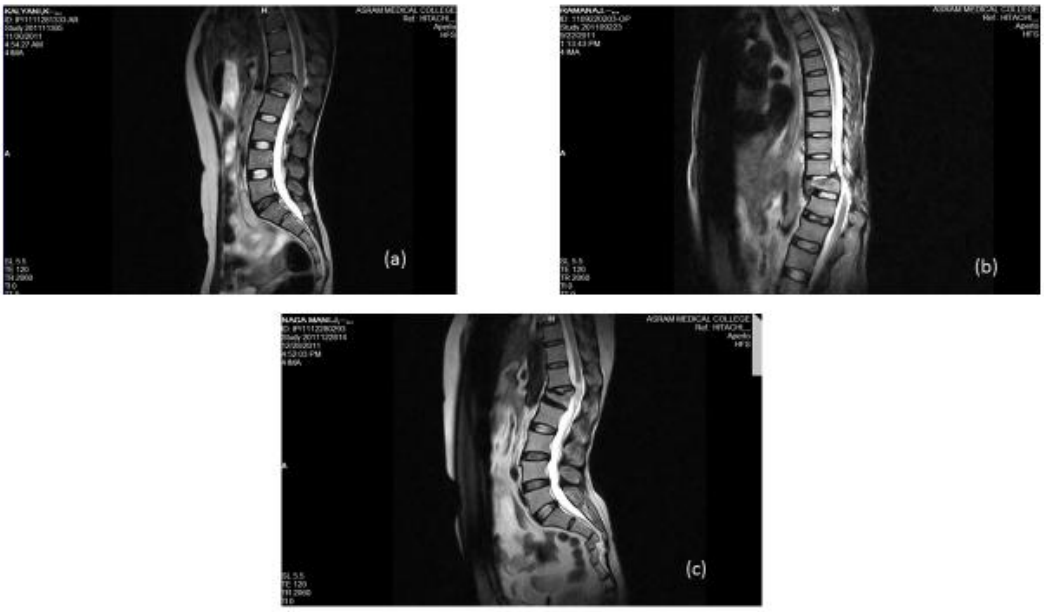

Fig 2(a) Burst fracture of L1 vertebral body with retropulsion of fracture fragment causing indentation on conus.
Fig 2(b)- Sagittal T2-weighted image Dorso-lumbar spine shows posterior dislocation of D11 causing compression on spinal cord.
Fig 2 ©--T2-weighted sagittal image of L-S spine showing wedge compression fracture of L1 vertebral body and hyperintensity of near CSF signal intensity in the conus, suggestive of myelomalacia changes due to previous injury.
Figure 3

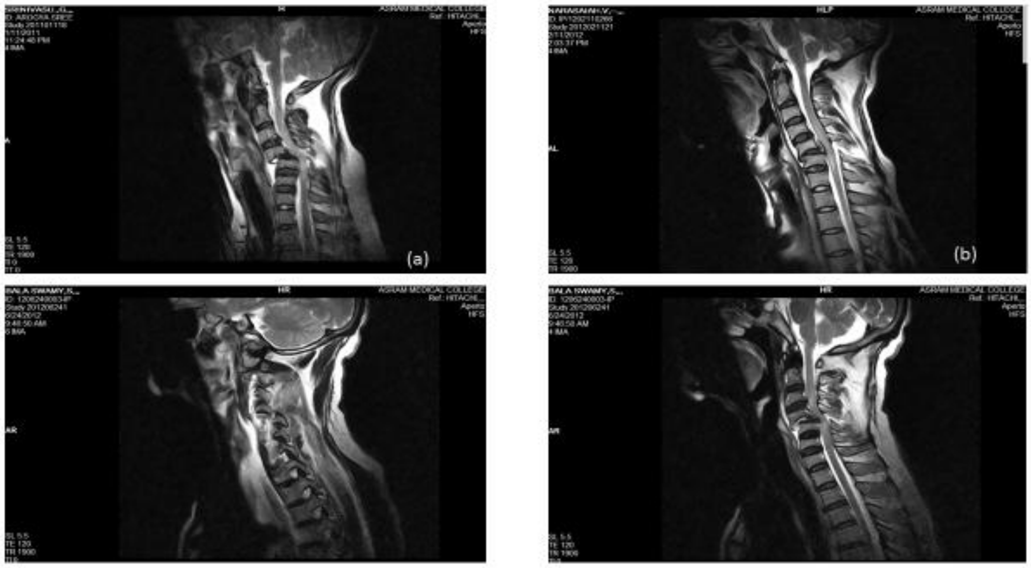

Fig 3 (a)-T2-weighted sagittal image of C-spine showing subluxation of C4 over C5 and disruption of anterior longitudinal ligament.
Fig 3(b)- T2-weighted sagittal image of C-spine showing subluxation of C5 over C6 and hyperintensity in the cord opposite C5,C6- suggestive of contusion.
Fig 3© & 3(d)-Grade II anterior subluxation of C4 over C5 with locked facet joint on left side, causing compression on cord. There is associated cord contusion, prevertebral collection and disruption of ALL,PLL and posterior ligamentous complex.

V. Discussion

The role of 'Magnetic Resonance Imaging' is unimaginable in the evaluation of spinal trauma particularly in patients with neurologic deficits where the bony injury is out of proportion. The signs of injury at one particular location obligate the radiologist to assess the integrity of the remainder of the osseo ligamentous complex including the spinal cord.

Classification of spinal trauma into acute and chronic categories is somewhat arbitrary. During the first week of spinal cord injury (SCI) most of the abnormal changes might have already occurred. The changes in the cord will progress or regress with time but there are no clinical or radiological markers that permit their separation into subacute and chronic stages(12) . However injury to the bony spine can be considered acute if it has occurred within 3 weeks.

The etiology of SCI are vehicular (37.4%), acts of violence (25.9%), falls (21.5%) and sports injury (7.1%) in USA. In our study fall from height accounted for in 50% individuals, followed by blunt trauma including assault in 25%cases. In our study the incidence of Motor vehicle accident (13.3%) causing spinal injury is less in comparision to studies of Kulkarni et al (1987)(19) and Silberstein et al (1992)(15) .

Nearly 33.3% of all SCI occurred in young adults at mean age of 26.5 years with an age range of 10 to 80 years in our study. The clinical presentation of SCI in Flanders et al study(14) 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 . In our study approximately one third of patients suffered complete quadriplegia and 23 cases suffered paraplegia with Bladder/bowel dysfunction occurring in two third of patients in the acute phase. The location of cord injury was highest at C4-C7 level followed by at T10-11 level in Rogers et al series (67) and similarly cord injury was highest in cervical followed by thoracic region in our study also (Chart-4).

Tarr et al (1) demonstrated vertebral body and posterior element fractures on T1WI .Vertebral body fractures were found in (50%) and (57%) of patients in Frankel-E and Frankel-A et al studies respectively with T1 hypo and T2 hyper intense signal relative to adjacent normal vertebral signal.Alteration in configuration of a vertebral body was the most reliable MR imaging sign of a fracture deformity(5) . Similar marrow signal changes were demonstrated in 66.7% of fractured vertebral bodies and 13.3% of posterior element fractures along with 45% of subluxations/ dislocations in the form of abnormal configuration in our study (Table 1).On MRI the ligamentous injury was well appreciated by the presence of their discontinuity or by noting indirect signs such as soft tissue hemorrhage and malalignment(16) .

Kulkarni et al precisely demonstrated the impingement of the thecal sac, spinal cord and nerve roots by retropulsed bony fragments, subluxated vertebrae or hematoma at the level of injury by MR imaging[3,1] .Compression/ angulation of the cord was well demonstrated in 17 cases (28.3%) due to retropulsion of the vertebrae in our study (Table 1) .

Extraspinal soft tissue abnormalities such as pre-vertebral soft tissue thickening and/or posterior ligamentous complex abnormalities were demonstrated in 48% scans by Kerslake et al [6] which were also associated with vertebral body fracture or fracture dislocation . They identified ALL and PLL injury as lifting up from underlying vertebral body by either heamatoma or disc protrusion. The ALL,PLL and supra or inter spinous ligamentous injury was also suspected by disruption of normal hypo intense black line on both T1 and T2 WI and also by presence of hyperintense signal on T2 WI in 43percent cases. In our study also the soft tissue and ligamentous injuries were diagnosed by similar morphological features and signal changes on MRI described by Kerslake et al. Paraspinal soft tissue changes were noted in 25 cases (41.6%) (Table 1) in the present study.

Kerslake et al (1991)[6] identified disruption of anterior longitudinal ligament (ALL) in 5 cases in the form of lifted ALL from the underlying vertebral body by either hematoma (presumed) or disc protrusion , four of which were thoraco-lumbar burst fractures. A diagnosis of posterior longitudinal ligament (PLL) rupture was not made in any case, probably reflecting the difficulty in identifying the PLL due to technical limitations of MRI scanner, rather than lack of PLL injury. The interspinous and supraspinous ligamentous complex injuries were seen/ suppected in 43% cases by Kerslake et al [6] as low signal on T1W and as high signal on T2W images [6]. These were accompanied by either vertebral column or intraspinal lesions in every case, and was considered as a marker of more severe injury[6] . Ligament injuries were diagnosed in our study also by similar signal changes and MRI features as described by Kerslake et al. There were 28 ALL (46.7), 38 PLL (63.3), 23 Ligamentum flavum/supra &interspinous ligament (38.3%) injuries (Table 1); There were also 25 (41.6) cases of Paraspinal soft tissue changes in our study which were associated with vertebral body/posterior element fractures and dislocations.

Different types of cord injuries like cord transection, necrosis, hemorrhage or edema can not be distinguished clinically but can be done by MR Imaging. On T1-weighted images, the spinal cord swelling is best shown[4]. On T2WI, focal increased signal probably represents edema/ contusion while focal dark signal represents the presence of deoxyhaemoglobin as a result of hemorrhage.

At high field strength (1.5T) , Kulkarni et al (1987)[3] described 3 patterns of cord damage in acutely spine injured patients corresponding to:

1. Central hemorrhage which increased with time.
2. Central petechial hemorrhage resolving with time.
3. Edema and contusion only.

Prognosis seems to relate to these categories, being worst in those with intraparenchymal hemorrhage of the spinal cord.

Further, Bondurant FJ et al[2] in 1990 described three patterns of MR signal changes in acute spinal injury patients:

Type1:Decreased signal intensity consistent with acute intraspinal hemorrhage.

Type2:Bright signal intensity consistent with acute cord edema.

Type3:Mixed signal intensity consistent with cord contusion .

In the same year Yamashita et al[11] said that patients with improvement of T2W hyperintensity had good neurological recovery, while patients with persistent hyperintensity on T2Wimages showed poor clinical improvement.

In all probability, abnormal signal intensities in acute stages represented edema, infarction, necrosis, and hemorrhage. The cord hemorrhage is seen as hypo intense signal immediately after insult and itreveals peripheral hyperintensity (edema) around central hypointensity(Deoxyhemoglobin) on follow-up MRI at 3-7 days .These changes progress to intramedullary cyst formation or Myelomalacia in chronic stage[12,18]. It is difficult to differentiate myelomalacia from cyst with MR imaging. However, the interface between the hypointense area and the surrounding spinal cord, internal architecture in the hypointense lesion, flow or turbulence of CSF, and spinal cord size are reportedly useful in such differentiation[11] .

In the present study, the contusion was rarely an isolated abnormality . Contusion with cord edema was evident in 50% of instances and Hemorrhoage was seen in 6.7% cases. Discernible edema with parenchymal hemorrhage in the cord was seen in 8 cases (13.4%), while transaction of spinal cord could be demonstrated in 5% MR examinations; evidence of associated skeletal injury was frequently present(Table 1). But Yamashita et al (1990)[11] expressed the opinion that patients with a central cord syndrome typically have no discernible osseous injury.

Cervical spine :

In a recent evaluation of cervical spine fractures, MR was found to have a sensitivity of 36.7% and 11.5% for anterior and posterior element fractures in comparison to computed tomography[19]. The sensitivity of MRI in detecting anterior subluxation is better than X-rays or CT.

Goldberg et al describedthat pre-vertebral swelling and ALL rupture were well associatedcervical spine fractures[7,20]. Thepresent study showed pre-vertebral abnormality in 3/22 cervical spine injury patients, one at C2-C3 and two at C4-C5 levels and they are consistently associated with ALL rupture (table 2).

Scheafer et al said that cervical cord contusions confined to one spinal segment or less were associated with less severe neurologic deficits than long segment contusions[17]. The present study theisolated cervical cord edemawasidentifiedin single segment at majority of levels, except in C6-C7segment where edema hasextended inmorethanone segment; but multisegment involvement was observed with hemorrhagic edema mostly in lower half of cervical spine (table 2).

Kerslake said -Hemorrhage occurs in the centre of the cord and it was the most precise indicator of the neurological level of injury.It occurs at the site of impact and was associated with bony and ligamentous damage[6]. Edema of the cord may extend above / below the level of hemorrhage and the length of edema directly correlates with the degree of neurological impairment but can not predict the level of Injury without hemorrhage.

Pratt et al[8] described that traumatic disc herniations with T2 hyperintense signal most commonly occurs at C4 to C7 levels. Similarly, out of the three cervical disc herniation one was seen at C4-C5 and two were observed at C5-C6 level. The severity of compressive damage to the neural elements depends on the size of the herniated intervertebral disc, and also on the dimensions of the cord and spinal canal at the level of injury[24].

Yamashita et al [13] identified subluxation of vertebral body , ossification of PLL, and osteophyte or herniated disc as most common causes of cord compression. In their study abnormal cord signal intensities were noted in 26 cases of which only 20 had cord compression, while six had no cord compression. In addition to the above mentioned causes , facet dislocations and epidural hematomas were also contributing for cord compression and signal changes in our study.

Thoracic spine:

Brightman et al [21] identified bony injuries well on plain radiographs and CT and cord/ligament injuries on MRI in their review of thoracic spine injuries. Similarlyin our study also MRI revealed ALL, PLL and supra and interspinous ligament disruption (Table 2). MRI also demonstrated the amount of vertebral collapse and the degree of encroachment on the subarachnoid space (Table 2). However the posterior neural arch fractures were not adequately delineated by MRI due to scant amount of epidural fat. .

Kulkarni et al[3] studied 27 patients with suspected spinal cord injury , of which 19/27 had cord abnormality and 21/27 had skeletal/ ligamentous injury on MRI. As in cervical cord injury, acute spinal cord hemorrhagewas seen in 5 cases as T2 hypointensesignal in the cord ; cord edema and contusion had high signal intensity on T2 weighted images and were observed in 12 cases with cord injury. Neurological recovery was insignificant in patients with intraspinal hemorrhage; however patients with cord edema or contusion recovered significant neurological function. In contrast to its appearance within the spinal cord, blood in the epidural space exhibits high signal on T1 weighted image and isointense signal on T2WI[10]. In the present study 2 instances of epidural hematoma with similar MR characteristics could be appreciated (table 2) in the upper thoracic (T1-T6) spinal injuries.

IVD herniation with cord compression was noted in two cases of T1-T6 segment, and in one case of T7-T10 segment injury in our study(table 2). An important association found in series of Flanders et al [27] was that cord edema and hemorrhage were always centered at the level of the bone, disk or ligament damage. In addition, when both vertebral fracture and an acute disc herniation were present, it was the intervertebral disc below the fractured vertebra that was most often responsible for cord compression.

Spinal cord swelling is defined as focal increase in caliber of the spinal cord with out signal change is also an indicator of cord dysfunction , may be associated with SCI[14] . It is best demonstrated on T1/ T2 weighted SE sagittal image as effacement of the surrounding subarachnoid space around the cord swelling[15]. In addition in the present study MR imaging revealed cord transaction also(table 2). While performing MR imaging of thoracic spine a sagittal survey of the cervical and lumbar spine with a large FOV can be used to detect non-contiguous concomitant fractures.

Penetrating injuries to the spine secondary to a knife or ‘gunshot’ wound may cause direct damage or compression of the spinal cord or nerve roots by blood clots or by bone fragments which can also be demonstrable by MRI[12].Spinal trauma patients developing myelomalacia on follow up MRI had a poor neurological outcome, similar to atrophy and syrinx[11]. . In the present study a case of small intramedullary cyst at D2 level could not be differentiated from myelomalacia change even by MRI.

Thoraco lumbar junction:

Fractures at thoraco-lumbar junction have a significant incidence of neurological deficit(40%) in series presented by Frankel et al (1994)[22]. The junction(T12-L1) is a transitional area and lacks structural stability because of abrupt change of facet orientation and subsequent motion restriction predisposes this area vulnerable for injury[24]. In addition, this segment is unique in spinal injury as it may result in trauma to both the spinal cord and cauda equina.

Fracture/subluxation was encountered in more than one third instances in this region in our study (table 2).The bony, ligamentous and cord/cauda equina injuries are identifiable on MRI by similar signal changes and morphometry as described earlier for cervical and sorsal spines.

Denis (1984)[23] described four basic types of thoraco-lumbar fractures: (1)compression fracture (2)burst fracture (3)seat belt injury (including chance fracture) (4) fracture dislocation. Compression fractures are most common type of lumbar fracture. While burst fractures involve the posterior aspect of vertebral body. Typically the posterior superior corner of vertebral body is disrupted and rotated to displace into the spinal canal. There is a controversy over whether the degree of displacement and canal compromise correlates with amount of neurologic symptoms.

Lumbosacral spine :

The lumbar spine is characterized by strong vertical facet joints with sagittal orientation, limiting axial movement and increasing the torsional stiffness. In Brightman series[21] of injury to the lumbar spine, cauda equina was common site of injury along with root compression and lumbar vertebral fractures.

Coronal (vertical) body clefts in adult are usually the result of of metabolic bone disease or the trauma. In traumatic cases, intervertebral discs herniated into the clefts and become apposed, without dessication of its central component[25]. The lumbar burst fractures with more than 50% spinal canal narrowing show an increased risk of instability and neural damage though there is poor correlation between neurologic deficit and spinal canal compromise .

An isolated incidence of trauma(trivial) to the 'sacral' segment of the spinal column was identified in present study where gross anterior dislocation causing complete obliteration of the sacral canal was observed. No mention of spinal trauma of such type could be reviewed in the available literature of MR imaging of injured spinal axis.

Overall MR abnormalities in Spinal Trauma:

In the present study, the extraspinal soft tissue changes in the prevertebral and / or posterior ligamentous complex were observed in 35/60 scans (58.3%). The vertebral column lesions were present in 54/60 examinations (90%), consisting of fracture/ dislocation and inter-vertebral disc injuries. The intra-spinal abnormalities were appreciated in 55/60 scans(90.3%), showing spinal cord contusion/ hemorrhage, cord compression, bony fragment and epidural hematoma(Table 4). Normal MRI examinations of injured spine were however excluded in the present set of study.

Beers et al described soft tissue injuries outside the spinal canal in cervical spine. Edema or hemorrhage was invisible on T2 weighted images in the pre-vertebral soft tissue in 10 out of 14 cases as high intensity areas lying anterior to the spinal column[4]. Edema or hemorrhage in soft tissue posterior to the spinal canal was evident on T2 weighted images in all but one patient. It is unclear at times how much of the hyperintensity was due to oedema and how much to haemoglobin derivatives.

In Kerslake study[6] -Vertebral column abnormalities were present in 27 examinations consisting of vertebral body/ neural arch fractures, shown by loss of normal contour or alteration of signal intensity. Focal canal stenosis was present in 17 cases in which 10/17 were due to fractures and the remaining 7/17 were due to intervertebral disc protrusions.

In the same authors study[6] intraspinal abnormalities were present in 25 scans (64%). These included extradural hematoma in 17 cases, spinal cord compression or displacement in 15 and cord contusion in 11 cases. The spinal cord was of normal morphology in eight patients, focally enlarged in two, and more diffusely swollen in one instance. The changes were confined to the level of spinal injury in all except one case which showed abnormalities extending over three spinal segments.

In general, it could be gathered in present study that the 'sagittal' orientation was far better for demonstrating spinal cord lesions than the axial images and MRI of spine has shown to have a high sensitivity for detecting traumatic cord edema and hemorrhage and spinal subluxations.

Summary And Conclusion

'Spinal 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 in that order. Most trauma cases occurred in middle age group with male predominance. Categorization of spinal trauma into acute and chronic is arbitrary. 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, ligamentous 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.

The limited number of cases in present study, inordinate delay between trauma and MR imaging and inconsistent clinical evaluation, made it difficult to correlate the MRI findings with neurological prognostic assessments.

The clinical impact of 'magnetic resonance imaging' is increasingly being realized for its utility in identifying the presence and extent of tissue damage in spinal injury for planning treatment strategies. It remains to be determined whether the use of MRI has a direct effect on improving the neurologic recovery and quality of life in persons afflicted with trauma of spine.

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