Imaging of Spinal Trauma by Magnetic Resonance Imaging and Computed Tomography

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Abstract:*MDCT is the preferred primary imaging modality in spine trauma patients. MRI gives superior contrast resolution for detection of soft tissue injuries and is the imaging modality of choice in detection of soft tissue injuries, spinal cord injuries, injury to intervertebral disc and ligaments. The aim of this study was to evaluate the role of MRI and MDCT in assessing the cord injuries, soft tissue injuries and bony injuries. The study was conducted on a total of thirty eight patients with spinal trauma which were referred between October 2015 & September 2017. All the cases were investigated using MDCT and MRI. Assessment of spinal trauma was done using both the imaging modalities in all the patients and the findings were studied under the following categories: Vertebral compression fractures, distraction fractures, posterior element fractures, vertebral listhesis, prevertebral soft tissue injuries, bone marrow edema, spinal canal narrowing, disc herniation, epidural hematoma, spinal cord injury and ligamentous injuries. In this cross-sectional study of 38 patients, 12 cases of Stable injuries and 26 cases of Unstable injuries were noted according to Denis classification. 108 fractures were identified by CT and out of these, 52 fractures demonstrated bone marrow edema on MR examination and 56 fractures didn't show any evidence of bone marrow edema. 76% of compression fractures showed bone marrow edema as compared to 33% and 26% in distraction fractures and other fractures respectively.MDCT was superior to rest of the imaging modalities in the diagnosis of vertebral fractures, however, it is insensitive to diagnosis of spinal cord injuries. MR Imaging is the only imaging modality to assess spinal cord injury.MR imaging should be considered a primary imaging modality to assess epidural hematoma, traumatic disc herniation, ligamentous injury and spinal cord compression. Other modalities can be used in patients in whom MR imaging is contraindicated. MDCT and MRI are complementary studies in spinal trauma.*

Keywords: Spinal trauma, MDCT, MRI

1. Introduction

Spinal trauma is a catastrophic event with associated high morbidity and mortality and many additional medical, psychological, social and financial consequences for patients, families and society. WHO recognizes it as a major musculoskeletal condition that presents a serious disease burden [1]. After a skull fracture the severity of disability is estimated at 43%. Following SCI, it is 72%! As per report of the International Conference (Spinal Injuries Management, New Delhi, 1995), the incidence of spinal injury was estimated at 15 new cases per million per year in India [2]. Most spine injuries follow road traffic collisions, falls, and sports injuries. Injuries of spine may produce neurologic deficit, which is critical and fatal sometimes [3].

Injuries to the spinal axis can be subdivided into Spinal Injuries (damage to the spinal axis without neurologic injury) and Spinal Cord Injuries (damage to the spinal cord with or without spinal axis abnormality). Tetraplegia is defined as an injury to one of the eight cervical segments of the spinal cord with paralysis of all four limbs. Paraplegia usually results from injury to the thoracic, lumbar or sacral segments of the spinal cord with dysfunction of both legs. A neurologically complete lesion is one in which there is no motor or sensory function three segments below the neurologic level of injury.

At many trauma centers, MDCT is the first imaging modality in spine trauma patients and has replaced radiography as the most cost-effective modality for imaging the cervical spine in high-risk patients. It has got higher sensitivity in detecting fractures, subcutaneous soft tissue trauma [4]. As compared to radiography, CT can detect fractures with greater accuracy, and assess whether a fracture is stable or unstable and whether the spinal alignment is maintained. However, MDCT increases the radiation by 50% and may increase the risk of cancer, particularly important consideration for children who have a long life expectancy [5].

MRI has become the most sensitive imaging modality for the diagnosis of most types of spinal injuries. MRI helps when MDCT is unable to adequately assess the cause of neurological deficits, determine acuity of a fracture, and assess for presence of ligamentous injury. When neurological findings are present that are not adequately detected by MDCT, spinal cord injury may have occurred and an extra–axial lesion like epidural hematoma or intervertebral disk herniation may be present [5].

In addition, coronal and sagittal images of MRI allow for better identification of soft tissue and ligament injuries. Given its multiplanar capacity, lack of ionizing radiation, ability to assess soft tissues and ligaments, the use of MRI in patients with spine injuries should improve the diagnostic precision, particularly with regard to the extension & localization of spinal cord injuries which cannot be delineated by MDCT [6].

Indications for performing MR Imaging include loss of neurologic function that cannot be explained by CT or CT myelography, suspected spinal cord injury, suspected extra-axial hematoma, suspected disc herniation that cannot be revealed by CT, absence of clinical improvement after a period of acute injury.

The major relative disadvantages of MR imaging are diminished ability to monitor acutely injured patients during the examination. MR scans take longer time than CT scans. During the scanning period the patients have to be closely monitored by the health care personnel due to the severity of injuries. Due to the closed configuration of the MR scanner, this process is made difficult. Cardiovascular monitoring devices and ventilator support machines which accompany the acutely injured patients with spinal trauma need to be MR-compatible.

2. Aims and Objectives

To evaluate the role of Magnetic Resonance Imaging and Multi Detector Computed Tomography in Spinal Trauma:
1) To assess the cord injuries and soft tissue injuries.
2) To assess the extent of bony injuries.

3. Methodology

This was a hospital-based,cross-sectional observational study. The study was conducted on 38 patients referred to the Department of Radiodiagnosis of K.S.Hegde Hospital, Deralakatte, Mangalorebetween October 2015 to September 2017. Patients with spinal injuries who underwent both CT and MRI during study period were included in the study. All scans were done using 1.5 Tesla MRI scanner& 16slice MDCT scanner.Non-contrast MDCT scans were performed with the patients in supine position on the table. The protocol included axial 5mm sections of the affected segments with reconstruction into 1.25mm sections and reformations in the axial, coronal and sagittal planes. Non-contrast MRI protocol included image acquisitions in the following sequences- T1W, T2W sagittal, T2W STIR in sagittal and coronal planes, T2W axial images of region of interest.

Assessment of spinal trauma was done using both the imaging modalities in all the patients and the findings were studied under the following categories: Vertebral compression fractures, distraction fractures, posterior element fractures, vertebral listhesis, prevertebral soft tissue injuries, bone marrow edema, spinal canal narrowing, disc herniation, epidural hematoma, spinal cord injury and ligamentous injuries.Data was analysed using standard statistical tests

4. Results

Table 1: Distribution according to cause of injury

Cause of Injury	Frequency	Percentage
Fall from height	22	57.80%
RTA	15	39.40%
Seatbelt injury	1	0.80%
Total	38	100%

Out of 38 cases of spinal injury, it was observed that most of the cases sustained injuries to the thoracolumbar spine i.e., 28 out of 38 cases(74%) and cervical spinal injuries accounted for 26% of cases.

Table 2: Distribution according to Denis Classification

Denis Classification	Frequency	Percentage
Single-column	9	23.6%
Two-column	15	39.4%
Three-column	11	28.9%

Table 3: Distribution of SCI in Stable and Unstable fractures

	Frequency	SCI Present	Percentage
Single-column	9	5	55.5%
Two-column	15	8	53.3%
Three-column	11	5	45.4%

Disc Herniations: Disc herniations were detected in 9/38(23.6%) cases on MRI. Out of these 2 cases were also detected on CT.

Spinal Epidural Hematoma: Epidural Hematoma was seen in 9/38(23.6%) cases. Out of these 9 cases, CT could detect 3 cases of epidural hematoma with a sensitivity of 33% as compared to MRI.

Spinal Cord Injuries: Out of 38 cases of Spinal trauma, 20(52.6%) cases had Spinal cord injuries and 18(47.4%) cases did not show evidence of Spinal cord injuries. Spinal cord hemorrhage was seen in 5(13.1%) cases. All the cases of spinal cord hemorrhage were accompanied by cord edema. Spinal cord swelling was seen in 19(50%) of cases. There was one case of complete transection of the cervical cord with associated cord edema and hemorrhage.

Vertebral Listhesis: Vertebral Listhesis was seen in 7 out of 38 cases of spinal trauma studied. All of the 7 cases were identified on both Computed Tomography and Magnetic Resonance Imaging.

Prevertebral Soft tissue Injury: 24 out of 38 cases of Spinal Trauma had prevertebral soft tissue injuries which was detected by MR Imaging.

Posterior Element Fractures: Out of 38 cases of spinal trauma, 27 cases showed evidence of posterior element fractures.There were 42 posterior element fractures identified on Computed Tomography. Out of these, only 30 posterior element fractures were identified on Magnetic Resonance Imaging.

Fractures and associated Bone Marrow Edema: Out of the 38 cases of spinal trauma, there were 108 fractures identified on Computed Tomography. The fractures were classified into Compression Fractures, Distraction Fractures, and fractures with no compression and distraction. 52 fractures out of 108 fractures demonstrated bone marrow edema and 56 out of 108 fractures did not demonstrate bone marrow edema. There were 46 compression fractures, 10 distraction fractures and 52 fractures that didn't show any evidence of compression or distraction.

Table 4: Distribution of fractures and marrow edema in the study population

	Compression Fractures	Distraction Fractures	Other Fractures
No. Of Fractures	46	10	52
No. Of fractures showing Bone Marrow edema	35	3	14
Percentage	76%	33%	26%

Table 5: Comparison of Marrow edema

Compression Fractures vs Distracted Fractures	Z=6.106	P=0.000, HS
Compression Fractures vs Other Fractures	Z=7.072	P=0.000, HS

Compared to distracted fractures and other fractures which didn't show compression or distraction, the compression fractures generated marrow edema with statistically significant p values.

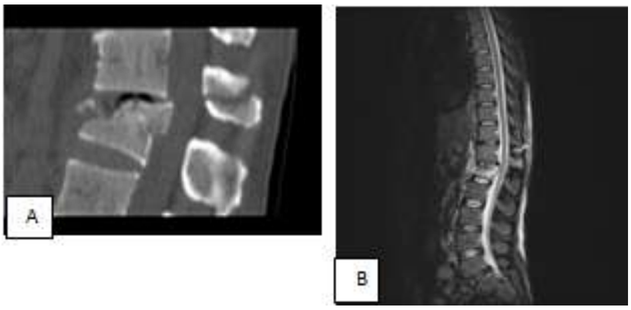

Figure 1: Chance fracture

A. Sagittal CT reconstruction in bone window shows Chance fracture L1 vertebra.

B. Sagittal STIR MRI through lumbar spine demonstrates bone marrow edema of L1 with a horizontal hypointense fracture line traversing the body andalso there is hyperintensity along the posterior column.

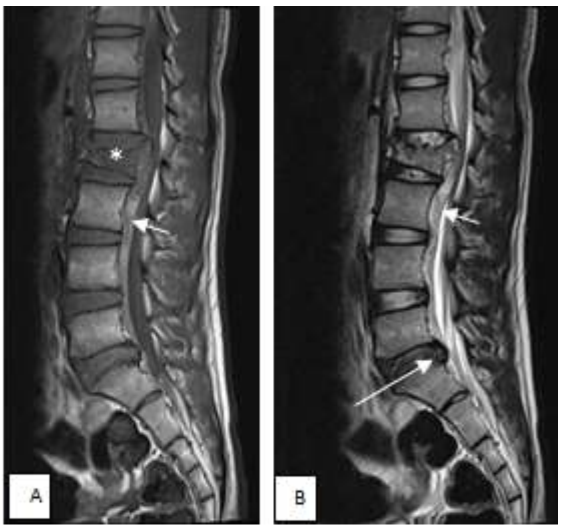

Figure 2: Burst fracture & Anterior Epidural Hematoma

A. Sagittal T1-weighted MRI through lumbar spine demonstrates compression fracture (white asterisk) of body of L2 vertebra with retropulsed fragment causing narrowing of the spinal canal, and a linear isointense collection (arrow) seen in the anterior epidural space extending distally**.**

B. Sagittal T2-weighted MRI through lumbar spine demonstrates compression of body of L2 vertebra more clearly with marrow edema and retropulsed fragment causing narrowing of the spinal canal, however the PLL is intact;and a linear hyperintense collection (small arrow) seen in the anterior epidural space extending distally**.** Incidentally there is also diffuse bulge at L5-S1 (long arrow).

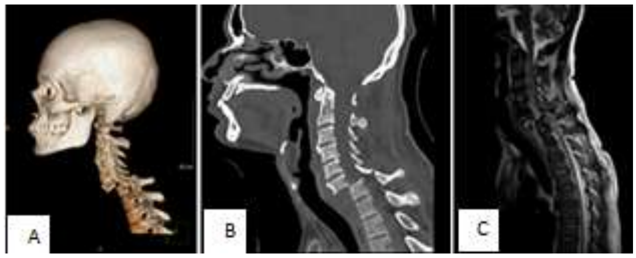

Figure 3: Displacement / translational injury

A.CT sagittal3D reformation of the cervical spine andskull showing translational injury at C6 -C7 level

B. Sagittal CT reconstruction in bone window showscomplete failure of all three vertebral columns.

C.Sagittal MRI through cervical spine demonstrates anterolisthesis of C6 on C7 with complete cord transection and disruption of anterior and posterior tension bands suggesting failure of all elements .

5. Discussion

Most common cause of spinal injury was fall from height in this study. Most of the literature provide motor vehicle accidents to be the most common cause of spinal injury. However, some authors have found that fall from height to be the most common etiology[7,8].

Most common location of the spinal injury was the thoracolumbar spine followed by cervical spine [9-11]. According to Richard E. Burney et al., cervical spine was the most common location involved in spinal trauma and there was high proportion of cervical spine involvement in motor vehicle accidents and fall from height [12]. In our study, thoracolumbar spine was predominantly involved and the proportion of thoracolumbar spine injuries was high compared to the cervical spine in victims of both motor vehicle accidents and falls.

According to Denis Classification, there were 9(23.6%) cases with Stable Injury and 26(68.4%) cases had unstable injury. The proportion of Stable and Unstable injuries having associated cord injuries was almost similar with 55% of cases having SCI in stable injuries and 50% of cases having SCI in unstable injuries.

MRI was better in diagnosing soft tissue injuries including prevertebral soft tissues, which were not detected even on High resolution Computed Tomography.

MRI was also better in detecting extramedullary lesions such as Intervertebral disc herniations and epidural hematoma. CT was less sensitive as compared to MRI in the diagnosis of Intervertebral disc herniations and epidural hematoma with a sensitivity of 22% and 33% respectively. According to James Provenzale[13], MRI is the most sensitive and specific imaging modality for the detection of intervertebral disc herniations and spinal epidural hematoma. This is in agreement to our study.

MRI has the ability to directly image the spinal cord and various spinal cord injuries including hematoma, edema and cord swelling can be easily seen on MR Imaging whereas in CT it is difficult due to beam hardening artifacts and poor soft tissue contrast [13]. In this study, there were five cases of spinal cord hemorrhage and one case of complete spinal cord transection. All five cases of spinal cord hemorrhage were accompanied with cord edema.

MRI was helpful in detecting bone marrow edema and was seen in 29 cases (52 sites). Fractures with vertebral compression generated marrow edema which was statistically significant whereas distraction fractures and other types of fractures did not reliably generate marrow edema. This is in keeping with the study done by Mark A. Brinckman et al. which says statistically significant differences in marrow edema were observed between vertebral body compression fractures compared to distracted fractures or those fractures that did not distract or compress [14].

According to Rowed DW et al. [15], patients with Ankylosing Spondylitis had high incidence of traumatic spinal epidural hematoma. In our study, there was a case of Ankylosing spondylitis with associated traumatic EDH.

6. Conclusion

MR Imaging is the only imaging modality to assess spinal cord injury, to diagnose location and the severity of the lesion, and also to detect the cause of spinal cord compression. This is helpful in the management of patients with incomplete spinal cord injury in whom, surgical intervention may prevent further deterioration.

MDCT is superior to rest of the imaging modalities in the diagnosis of vertebral fractures. However, it is insensitive to diagnosis of spinal cord injuries. While CT is considered adequate for determination of stable vs unstable spinal injuries, MRI can offer additional help due to its ability to better diagnose ligamentous injuries when compared with CT. Therefore, MRI is the ideal investigation to be done whenever spinal cord lesion or ligamentous injury is suspected.

MR imaging should be considered as a primary imaging modality in assessing epidural hematoma, traumatic disc herniation and ligamentous injury. Other modalities can be used in patients in whom MR imaging is contraindicated.

MR Imaging does not offer any advantage over MDCT in the assessment of bony injuries. MR Imaging is less sensitive than MDCT in the diagnosis of vertebral fractures,however it can demonstrate bone marrow edema in cases of compressive injuries. MDCT and MRI are complementary studies in imaging of spinal trauma.

Bone marrow edema on MRI is an indicator of acuity of fracture and not all fractures generate bone marrow edema. Radiologists should be aware of bone marrow edema patterns and the type of fractures which generate bone marrow edema to avoid false negative MRI examination.

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