PROGNOSTIC VALUE OF MAGNETIC RESONANCE IMAGING FINDINGS IN ACUTE SPINAL TRAUMA

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ABSTRACT

AIM
To assess the prognostic value of MRI findings in acute spinal trauma by assessing the neurological outcome after an interval period (3-4 months) and correlating it with the different MRI patterns of injury.

METHODOLOGY
Sixty patients with acute spinal trauma presenting to Calicut Medical College with neurological deficit for MR imaging were included in the study after applying the inclusion and exclusion criteria. MRI imaging of the spine was done and patients were divided into three groups based on the MR imaging pattern of cord injury (single level oedema, multi-level oedema, and cord haemorrhage). Neurological status of the patients were assessed at the time of presentation and at the followup period. Neurological outcome was categorised into good, fair, and poor based on the change in neurological status over the followup period.

RESULTS AND INTERPRETATION
In the study population, frequency of Spinal Cord Injury (SCI) was more common in males (90%) compared to females (10%). Majority of the patients belonged to the 20-60 years age group with highest incidence in 41-60 year age group and less number of patients at extremes of age. Most common cause was found to be road traffic accident followed by fall, assault, and sports injury. Cervical cord was the most commonly affected in traumatic injuries of the spine. There was statistically significant association between PLL injury and neurologic outcome. Statistically significant association was found between the neurologic outcome and the abnormal MRI signal patterns of cord injury.

CONCLUSIONS
MRI is useful for not only for initial diagnosis of acute spinal cord injury, but also for its prognostication and predicting neurological recovery.

KEYWORDS
Spinal Trauma, MRI, Prognosis, SCI, Acute Spinal Cord Injury.


INTRODUCTION
Spinal Cord Injury (SCI) is a traumatic event that results in disturbances to normal sensory, motor, or autonomic function and ultimately impacts a patient’s physical, psychological, and social wellbeing. The management of SCIs requires significant healthcare resources and can place a substantial financial burden on patients, their families, and the community. In 2011, Gripps et al reported the global prevalence of SCI to be between 236 and 1,009 per million. Traffic accidents were typically the most common cause of SCI followed by falls in the elderly population.

The traditional therapeutic interventions for SCI were directed primarily by radiographic findings and included reestablishment of normal anatomic alignment of the spinal canal and removal of bone fragments. Current management of SCI, however, has become more directed toward correction of the spinal cord and associated soft tissue damage and MRI has become increasingly important in the diagnostic evaluation of spinal injuries. Many advantages of MRI such as higher contrast resolution, absence of bony artefacts, multiplanar capability, and choice of various pulse sequences make possible to diagnose spinal trauma more accurately. More adequate information about neural and extraneural injuries requiring surgical interventions; for example, significant disc herniations and epidural haematomas can be obtained. The depiction of parenchymal SCI (spinal cord oedema, contusion, haemorrhage, and ischaemia) on MRI is said not only to correlate well with the degree of neurologic deficit, but also to bear significant implications in regard to prognosis and potential for neurologic recovery. This led to the selection of this study to assess the prognostic value of MRI in acute spinal trauma. Such a correlation would be helpful to the clinician in...
giving expeditious patient centred management, avoidance of unnecessary procedures, better patient counselling, and future planning of rehabilitation programs. Furthermore, it helps to improve medical strategies to achieve the best outcome, plan, and design appropriate research, and test new drugs efficacy.6

**AIMS AND OBJECTIVES**

To assess the role of Magnetic Resonance Imaging as a prognostic tool in acute spinal trauma by assessing the neurological outcome after an interval period (3-4 months) and correlating it with the different MRI patterns of cord injury.

**METHODS**

**Study Design**

Cohort study.

**Study Setting**

Government Medical College Hospital, Calicut.

**Study Period**


**Sample Size**

All cases during the study period satisfying the inclusion and exclusion criteria in whom neurological deficit could be assessed at the time of initial presentation and at the followup period were included in this study. Sixty such cases were obtained during the study period and these patients were included in the study.

**Study Subjects**

The study sample was comprised of sixty patients who presented with neurological deficit for MR imaging of the spine following acute spinal trauma.

**Inclusion Criteria**

All consecutive patients with acute spinal trauma presenting to Calicut Medical College with neurological deficit for MR Imaging.

**Exclusion Criteria**

1. Patients with history of previous neurological deficit due to vascular and other insults prior to the traumatic event.
2. Patients who had an initial MRI done for acute spinal trauma, but expired before the followup period of 3-4 months.
3. Patients who had an MRI done for spinal trauma, but in whom the neurological deficit couldn’t be assessed either at the time of presentation or at the followup period due to patient or logistical reasons.
4. Patients who had no signal changes in the cord and had neurological deficit due to other reasons.

**Study Methodology**

Using Frankel’s classification of neurological deficit,7 the neurological status of the patient was assessed at the time of initial presentation after spinal trauma. A followup assessment of neurological deficit was done later at 3-4 months after the trauma.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Complete neurological injury-no motor or sensory function clinically detected below the level of the injury.</td>
</tr>
<tr>
<td>B</td>
<td>Preserved sensation only-no motor function clinically detected below the level of the injury; sensory function remains below the level of the injury, but may include only partial function.</td>
</tr>
<tr>
<td>C</td>
<td>Preserved motor non-functional-some motor function observed below the level of the injury, but is of no practical use to the patient.</td>
</tr>
<tr>
<td>D</td>
<td>Preserved motor function-useful motor function below the level of the injury; patient can move lower limbs and walk with or without aid, but does not have a normal gait or strength in all motor groups.</td>
</tr>
<tr>
<td>E</td>
<td>Normal motor-no clinically detected abnormality in motor or sensory function with normal sphincter function; abnormal reflexes and subjective sensory abnormalities maybe present.</td>
</tr>
</tbody>
</table>

Images were obtained with the help of 1.5T GE 1.5T Sigma HDx 16 Channel MRI scan system installed in Calicut Medical College. Sagittal T1 and T2 weighted images, Axial T1, T2 weighted images, Coronal STIR, Sagittal MERGE images were routinely obtained.

Three MRI patterns of cord injury were defined based on the different signal patterns described by Kulkarni et al,8 Bondurant et al,9 and Schaefer et al.10

**Pattern 1:** Single level non-haemorrhagic contusion/oedema (hyperintense signal on T2 at single level in the spinal cord with no blooming in MERGE images).

**Pattern 2:** Multilevel non-haemorrhagic contusion/oedema (hyperintense signal on T2 at multiple vertebral levels in the spinal cord with no blooming in MERGE images).

**Pattern 3:** Haemorrhagic contusion (hypointensity on T2 surrounded by area of hyperintensity in the spinal cord with blooming in MERGE images).

Single level oedema was taken as oedema of length, which is equal to or less than the height of adjacent one vertebral body. Multilevel oedema was taken as oedema of length greater than height of adjacent 1 vertebra.

**Outcome**

Neurological deficit at time of presentation and at time of followup was assessed using Frankel’s grading system and graded from A to E. Outcome was graded as good if the neurological improvement was >2 grades on Frankel’s grade or if patient improved completely with no neurological deficit at followup period; fair if improvement was 1 or 2 grades only and poor if the grade at the 3-4 months followup remained unchanged or even deteriorated.

**Statistical Analysis**

Patients were divided into 3 groups based on the MRI signal patterns of cord injury. Three different outcomes were defined as previously mentioned and statistical analysis was done to see if there was a significant association between the different patterns of injury and the neurological outcome. It was considered to be significant if P value was <0.05.
RESULTS

Sex-Wise Distribution of Patients
In the study population, majority of patients were males (90%) with females constituting only 10%.

Age Distribution of Patients
Among the study population, 6.67% belonged to age <20 years of age, 35% belonged to 20-40 years of age, 51.67% belonged to 41-60 years of age and 6.67% belonged to >60 years of age.

Part of Cord Involved
In the study population, 51.7% had isolated cervical cord involvement, 18.3% had isolated thoracic cord involvement, and 13.3% had isolated lumbar cord involvement, 6.7% had involvement of both cervical and dorsal cords; and 10% had involvement of both thoracic and lumbar cords.

Cause of Spinal Cord Injury
In the study population, cause of majority of patients with spinal cord injury was RTA (73.3%), followed by fall (18.3%), assault (6.7%), and sports injury (1.7%).

ALL injury
In the study population, 86.7% had no ALL injury, 8.3% had partial tear, and 5.0% had complete tear.

PLL Injury
In the study population, 63.3% had no PLL injury, 21.7% had partial tear, and 15.0% had complete tear.
MRI Patterns of Cord Injury
In the study population, 20% belonged to MRI pattern 1 (single level oedema), 51.7% belonged to MRI pattern 2 (multiple level oedema), and 28.3% belonged to MRI pattern 3 (cord haemorrhage).

Neurological Deficit at Presentation (Frankel’s Grade)
Among the study population, at the time of presentation, 45% belonged to Frankel’s grade 1, 13.3% belonged to Frankel’s grade 2, 36.7% belonged to Frankel’s grade 3, and 5% belonged to Frankel’s grade 4 of neurological deficit.

Neurological Deficit at Followup (Frankel’s Grade)
Among the study population, at the time of followup, 23.3% belonged to Frankel’s grade A, 6.7% belonged to Frankel’s grade B, 26.7% belonged to Frankel’s grade C, 36.7% belonged to Frankel’s grade D, and 6.7% belonged to Frankel’s grade E of neurological deficit.

Neurological Outcome
In the study population, 11.7% had good neurological outcome, 53.3% had fair outcome, and 35% had poor neurological outcome.

Change in Grade of Neurological Deficit
The average change in grade of neurological deficit was 0.59 for pattern 3, 1 for pattern 2, and 1.33 for pattern 1.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.33</td>
<td>.985</td>
<td>.284</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1.00</td>
<td>.816</td>
<td>.147</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>.59</td>
<td>.795</td>
<td>.193</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>.95</td>
<td>.872</td>
<td>.113</td>
</tr>
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</table>

Table 1: Change in Grade of Neurological Deficit
Relation between Neurological Outcome and MRI Patterns of Cord Injury

<table>
<thead>
<tr>
<th>Neurological Outcome</th>
<th>MRI Patterns of Cord Injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Fair</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 2: Relation between Neurological Outcome and MRI Patterns of Cord Injury

Chi-Square Tests to look for Relation between Neurological Outcome and MRI Patterns of Cord Injury.

On applying the chi-square test, significant association was found between neurological outcome and the MRI patterns of cord injury (P value <0.001).

Correlation between PLL Injury and Neurological Outcome

Chi-Square Tests to look for Relation between PLL Injury and Neurologic Outcome.

Significant association is noted between PLL injury and neurologic outcome (P value 0.021).

Relation between ALL Injury and Neurological Outcome

Chi-Square Tests to look for Relation between ALL Injury and Neurologic Outcome

No significant association is noted between ALL injury and neurologic outcome (P value 0.088).

Graph 11: Relation between Neurological Outcome and MRI Patterns of Cord Injury

Table 2: Relation between Neurological Outcome and MRI Patterns of Cord Injury

<table>
<thead>
<tr>
<th>Neurological Outcome</th>
<th>MRI Patterns of Cord Injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Fair</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>31</td>
</tr>
</tbody>
</table>

Graph 13: Relation between All Injury and Neurological Outcome

Chi-Square Tests to look for Relation between ALL Injury and Neurologic Outcome

No significant association is noted between ALL injury and neurologic outcome (P value 0.088).

Graph 12: Correlation between PLL Injury and Neurological Outcome

Chi-Square Tests to look for Relation between PLL Injury and Neurologic Outcome.

Significant association is noted between PLL injury and neurologic outcome (P value 0.021).
DISCUSSION

In my study, sixty patients who came after acute spinal trauma with neurological deficit for MR imaging of the spine were studied.

In the study population, frequency of spinal cord injury was more common in males (90%) compared to females (10%). This may be due to the fact that males indulge in strenuous and high velocity activities and are thus more prone to injuries.

In the study population, 6.67% belonged to age <20 years of age, 35% belonged to 20-40 years of age, 51.67% belonged to 41-60 years of age, and 6.67% belonged to >60 years of age. Majority of the patients thus belonged to the 20-60 years age group with higher incidence in 41-60 year age group and only 13.3% patients at extremes of age (i.e., less than 20 and more than 40). Epidemiological data from the 1980s show that SCI primarily affects young adults (mean age: 29 years). During the last three decades, however, the proportion of elderly SCI subjects has increased considerably.\textsuperscript{11,12} Currently, the average age at injury is estimated to be 45 years.\textsuperscript{13} The mean age in my study was 41.43 with standard deviation of 14.37, which is consistent with the global average.

In the study population, the most common cause of SCI was found to be RTA (73.3%), followed by fall (18.3%), assault (6.7%), and sports injury (1.7%). Spinal cord injuries require high velocity and heavy force trauma, which is most commonly caused by RTA.
seen in road traffic accidents. Globally also, motor vehicle accidents are the principal cause of spine trauma and account for approximately 40% of reported cases.14

In the study population, 51.7% had isolated cervical cord involvement, 18.3% had isolated thoracic cord involvement, and 13.3% had isolated lumbar cord involvement, 6.7% had involvement of both cervical and dorsal cords; and 10% had involvement of both thoracic and lumbar cords. This finding is also in accordance with the global average according to which half of spinal injuries occur in the cervical spine.14

In this study, the neurological deficit at the time of presentation and at the time of followup were assessed using Frankel classification. At the time of presentation, 45% belonged to Frankel’s grade A, 13.3% belonged to Frankel’s grade B, 36.7% belonged to Frankel’s grade C, and 5% belonged to Frankel’s grade D of neurological deficit. At the time of followup, 23.3% belonged to Frankel’s grade B, 67.6% belonged to Frankel’s grade C, 36.7% belonged to Frankel’s grade D, and 6.7% belonged to Frankel’s grade E of neurological deficit.

Three MRI patterns of cord injury (single level oedema, multi-level oedema, and cord haemorrhage) were defined based on the descriptions of different signal patterns in cord by Kulkarni et al8 and Bondurant et al.15 In our study, 20% belonged to MRI pattern 1, 51.7% belonged to MRI pattern 2, and 28.3% belonged to MRI pattern 3 of cord injury. The neurological outcome was then graded into three types (Good, fair, and poor) depending upon the degree of neurologic recovery. In the study population, 11.7% had good neurological outcome, 53.3% had fair outcome, and 35% had poor neurological outcome.

In our study, injury to ALL was comparatively less (12.3%); and out of that, 62.5% had partial tear and rest had complete tear. Injury to PLL was seen in 36.7% (21 patients) of patients and out of that 59% had partial tear and the rest had complete tear. In the study (Spinal Cord Injury after Blunt Cervical Spine Trauma: Correlation of Soft-Tissue Damage and Extension of Lesion) by Martinez-Perez et al,16 52.8% patients had ALL injury and 58.3% patients had PLL injury. Our study showed a reduced frequency of ALL injury and PLL injury. But, we have studied cases involving all parts of the spinal cord and not cervical cord alone. In the study by Silberstein et al,17 a positive correlation is shown between ligament injury and neurologic outcome with patients having ligament injury showing a worse outcome (P value 0.045). Our study showed a significant association between PLL injury and neurologic outcome (P value 0.021), but no significant association between ALL injury and neurologic outcome (P value 0.088). This may be due to close proximity between PLL and the spinal cord making the spine more unstable and leading to more cord damage.

Of all patients who had poor neurological outcome (21 patients in total, out of 60), highest frequency (47.6%) belonged to pattern 3 (haemorrhagic contusion) closely followed by pattern 2 (multilevel oedema) (42.86%). Only 9.5% patients belonging to pattern 1 (single level oedema) had poor neurological outcome. Of all patients with cord haemorrhage (17 patients), 58.8% had a poor outcome and rest had a fair outcome. No patient with cord haemorrhage had a good outcome. Among our study population, highest frequency of patients with fair neurological outcome belonged to pattern 2 of spinal cord injury (65.62%) followed by pattern 3 (21.88%) and pattern 1 (12.50%) showing that pattern 2 (multilevel oedema) is less severe compared to pattern 3 (cord haemorrhage). Highest number of patients with good neurological outcome belonged to pattern 1 of spinal cord injury (85.71%) followed by pattern 2 (14.29%) showing pattern 1 (single level oedema) to be least severe. On application of chi-square test, a significant association was obtained between the neurologic outcome and the abnormal MRI signal patterns (P value <0.001). These findings are in agreement with previous observations made by Kulkarni et al,8 Bondurant et al,15 Arnold et al,18 Si et al,17 Andreoli et al,19 Ramon et al,20 Shimada et al,21 Parashari et al,22 and Singh et al.23 The average change in grade of neurological deficit was 0.58 for pattern 3, 1 for pattern 2, and 1.33 for pattern 1.

Thus, MRI is useful for not only for initial diagnosis of acute spinal cord injury, but also for its prognostication and predicting neurologic recovery.

REFERENCES


