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Reliability of Magnetic Resonance Imaging in Determining Status of Posterior Ligamentous Complex in Thoracolumbar Spinal Fractures

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ABSTRACT

Introduction: Spinal stability depends significantly on the posterior ligamentous complex (PLC) which necessitates determining its status before deciding treatment plan for thoracolumbar injuries. Magnetic Resonance Imaging (MRI) has gained more importance in diagnosing PLC status than other indirect methods.

Objectives: This study aimed to evaluate the reliability of MRI in determining the status of PLC in thoracolumbar spinal fractures.

Methodology: Thirty-three patients who sustained thoracolumbar spinal injuries and required surgery were included. They were evaluated by palpation of the interspinous gap, plain radiograph, and MRI. The radiologist and the surgeon classified PLC status as intact, incompletely disrupted, or disrupted based on MRI and intraoperative findings respectively. The relation between clinical, radiological, and MRI findings was compared with intraoperative findings.

Results: A wide interspinous gap was palpated in 9 patients and was found in 14 patients on plain radiographs. MRI showed PLC injury in 20 patients whereas 19 patients had PLC injury shown by intraoperative findings. MRI showed a significant relation with intraoperative findings. There was almost perfect agreement between the radiologist's interpretation and the intraoperative findings for various components of PLC. MRI sensitivity for diagnosis of each component of PLC varied between 89.1% (interspinous ligament) and 98% (ligamentum flavum). Specificity varied between 68% (facet capsules) and 100% (SSL).

Conclusion: MRI has a high sensitivity, specificity, and reliability for diagnosing injury of PLC in thoracolumbar spinal injuries so it can be considered as an important diagnostic tool for treatment plans.

Introduction

Spinal fractures are common injuries worldwide and are major cause of disability in adults. The mortality rate following spinal injury is 7% and the injury commonly occurs between the T11 and L4 vertebrae.[1,2] Spinal stability relies on integrity of both bony and ligamentous components, and injury to either or both of these components leads to spinal instability.[3,4]

While bony components can be evaluated using radiographs and CT scans, they do

not provide an accurate assessment of ligamentous structures.[3,5] Soft tissue structures including Posterior Ligamentous Complex (PLC) are crucial for spinal stability.[3,6,7]

The treatment outcome depends on the status of the PLC which can be indirectly evaluated through physical examination, radiography, and MRI.[6] However, operative findings are considered gold standard for determining actual status of the PLC in spinal fractures.[3]

Previous studies have examined diagnostic accuracy of MRI in assessing the PLC status, but results have varied[.6,8] This study aims to further investigate the reliability of MRI in determining the status of the PLC in thoracolumbar spinal fractures.

Methodology

Prospective observational study was conducted at the National Trauma Center in Katmandu, Nepal, over a period of one year from May 2021 to April 2022. The study population consisted of patients with thoracolumbar spinal fractures who were attending the Emergency Department and undergoing surgery. Convenience sampling technique was used, and the calculated sample size was 33.

Sample size Calculation:

Sample Size, n= z2se(1-se)/d2, n= 33

Where,
Z=1.96, taking 95% confidence interval
se= 0.905(90.5%) sensitivity of MRI for determining status of PLC as shown by previous study 8
d = maximum tolerable error = 10%

Therefore,
n= 1.962*0.905*0.095/0.12 = 33

The inclusion criteria for the study were patients aged 18 years and above with thoracolumbar burst fractures undergoing surgical management. Exclusion criteria involved patients with pathological fractures, osteoporotic fractures, malignant diseases, a history of previous surgery for spinal disorders, and old traumatic fractures.

Ethical clearance was obtained from the Institutional Review Board (IRB) of the National Academy of Medical Sciences (NAMS). Informed consent was obtained from all the patients before enrolling them in the study. Demographic data, mode of injury, and neurological status were recorded. Radiographs, CT scans, and MRI of the thoracolumbar spine were performed following the hospital's standard protocol.

The status of each component of Posterior Ligamentous Complex (PLC) as described by the radiologist in the pre-operative MRI was noted. The patient then underwent surgery, and the intraoperative status of each component of the PLC was carefully observed by the surgeon. MRI findings and intraoperative findings were compared, and appropriate statistical analysis was performed.

Data collected during the study were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25 for Windows. Statistical tests, such as chi-square test and Spearman's rank-order correlation, were used to determine the relationship between variables. Cohen's Kappa Coefficient was calculated to assess the agreement between MRI findings and intraoperative findings. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were also calculated. The significance level was set at 95% with a p-value of less than 0.05.

Results

The study included 33 patients, with 24 being male and 9 females, and the mean age was 34.1 years. The majority of fractures occurred in the thoracolumbar region (T10-L2) in 73% of cases, followed by the lumbar region (L3-L5) in 15% of cases and the thoracic region (T1-T9) in 12% of cases. Most fractures were classified as burst fractures (21 cases), followed by translation injuries (7 cases) and compression and distraction fractures (2 cases each).

The most common mode of injury was a fall from height (76%), followed by motor vehicle accidents (18%). In terms of neurological status, most patients had ASIA E neurology (15 cases), indicating normal sensory and motor function, followed by ASIA A (complete motor and sensory loss, 11 cases), ASIA D (motor function preserved, 5 cases), ASIA B (sensory preserved, 1 case), and ASIA C (motor function preserved below the level of injury, 1 case).

Regarding the status of the Posterior Ligamentous Complex (PLC), clinically, 9 patients were found to have a disrupted PLC, and radiologically, 12 patients showed PLC disruption. However, MRI findings revealed PLC disruption in 20 patients, while operative findings indicated disruption in 19 patients. In both MRI and operative findings, any disruption of a component of the PLC was considered as a disrupted PLC. Table 1 shows the frequency distribution of PLC status as seen in MRI and intraoperatively.

Table 1: Frequency distribution of PLC status as seen in MRI and Intraoperative findings

PLC Structure	Intact		Partially Disrupted		Disrupted	
	MRI Finding	Operative Finding	MRI Finding	Operative Finding	MRI Finding	Operative Finding
Supraspinous Ligament	16	14	6	8	11	11
Interspinous Ligament	15	14	7	8	11	11
Ligamentum Flavum	13	13	9	9	11	11
Facet Capsule	16	22	7	2	10	9

Each patient was palpated at the fracture level and interspinous gap was noted. Similarly, interspinous distance widening was noted at fracture level on radiographs. Presence of interspinous gap on palpation and increased interspinous distance on radiographs was considered as injured PLC. In same way, MRI findings for each component of PLC was noted. Then, these findings were compared to that of intraoperative status of each component of PLC. Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) were calculated for each component. Table 2 shows the sensitivity, specificity, PPV and NPV of different methods for predicting PLC injury.

Table 2: Sensitivity, specificity, PPV, NPV of different methods

		Sensitivity	Specificity	PPV	NPV
Palpation		31.6	78.6	66.7	45.8
X-ray		52.6	71.4	71.4	52.6
MRI	SSL	89.5	100	100	87.5
	ISL	89.5	92.8	94.4	86.7
	LF	95	92.3	95	92.3
	FC	90.9	68.2	58.8	93.8

There was no statistically significant relation between findings on palpation (wide interspinous gap) as compared to operative findings ($\chi2 = 0.021$, p=0.886). Similarly, there was no statistically significant relation between x-ray finding (increased interspinous distance) as compared to operative finding ($\chi2 = 2.344$, p=0.126). However, statistically significant relation was found between MRI findings and operative finding ($\chi2 = 29.111$, p=0.000).

Cohen's Kappa Co-efficient calculation showed an almost perfect level of agreement between MRI findings and operative findings for supraspinous, interspinous, and ligamentum flavum whereas substantial level of agreement was present for facet capsules. Table 3 shows strength of agreement between MRI finding and operative finding based on Cohen's Kappa co-efficient.

Table 3: Agreement between radiologist's MRI finding and Surgeon's operative finding

PLC Component	Cohen's Kappa	Strength of Agreement
Supraspinous	0.878	Almost Perfect
Interspinous	0.939	Almost Perfect
Ligamentum Flavum	0.936	Almost Perfect
Facet Capsule	0.640	Substantial

Significant correlation between neurological status and status of each component of PLC was found (p <0.01). Table 4 shows the correlation between the neurological status and PLC status.

Table 4: Correlation between neurology and PLC status

PLC Component	Spearman's Correlation Co-efficient	P value
Supraspinous	0.916	<0.01
Interspinous	0.916	<0.01
Ligamentum Flavum	0.893	<0.01
Facet Capsule	0.867	<0.01

Discussion

Vertebral fractures with injury to the spinal cord are common in trauma patients and a delay in diagnosis result in up to an eightfold increase in neurologic deficits.[9,10] Neurological injury depends on how stable the fracture is and stability in turn depends upon bony as well as ligamentous integrity. Studies done by Lee et al[3] and James et al[11] have shown that spinal stability is primarily determined by integrity of PLC status. Similarly, Vaccaro et al[7] in their Thoracolumbar Injury severity and Scoring System (TLICS) classification system has also given importance to integrity of PLC in clinical decision making for management of thoracolumbar spinal fractures. Whereas bony structures are well evaluated by plain radiographs and CT scan, MRI plays an important role in screening and evaluating patients for ligamentous injuries.

Majority of the patients in our study was male (73%) and the mean age was 34.1 years which was similar to study done by Dai et al[12] suggesting that spinal fractures are relatively common in young males. This might have been because of more work-related trauma in young males.

Thoracolumbar region (T10-L2) was the commonest level of fracture (73%) which was similar to study done by Shetty et al suggesting thoracolumbar junction to be commonest level of spinal fractures.[13] Similarly, burst fracture was the commonest type of fracture. Fall from height was the commonest mode of fracture followed by motor vehicle accidents which was in contrast to study done by Shetty et al where motor vehicle accident was the commonest mode of injury.[13] Fall from height as the commonest mode of injury might have been because of geographical differences that we have as compared to other studies as more people live in hills and mountains resulting in accidental fall injuries.

Among 33 patients in our study, MRI showed 20 patients had disrupted PLC whereas only 19 patients had actually disrupted PLC as shown by intraoperative finding. This shows MRI often over diagnoses PLC injury which was similar to study done by Shetty et al.[13] Clinically and radiologically only 9 and 12 patients with PLC disruption respectively were found out of 19 actually disrupted PLC as shown by intraoperative finding. Similar findings were shown by Shetty et al and Lee et al.[3,13]

Statistically significant relation was neither found between findings on palpation (wide interspinous gap) and intraoperative findings nor between x-ray finding (increased interspinous distance) and operative finding. However, statistically significant

relation was found between MRI findings and operative findings which was similar to study done by Lee et al.[3] Similarly, this study showed that clinical method (palpation) had a sensitivity of 26.3% which was lower than study by Lee et al and specificity of 71.4% which was slightly higher than study by Lee et al in accurately detecting status of PLC.[3] These findings suggests that clinical method (palpation) and plain radiographs which are often used to indirectly estimate the status of PLC are not reliable and clinical decision should not be based on them only.

This study showed that sensitivity of MRI for detecting injury to different components of PLC ranged from 89.5% to 90.9% and specificity ranged from 58.8% to 100% for different components of PLC. This result was similar to most of previously done studies except that done by Vaccaro et al and Shetty et al.[6,13] Haba et al had concluded that the sensitivity and specificity of MRI in diagnosing supraspinous and interspinous ligament injury was 90.5% and 94.3%, respectively, with a near- perfect agreement according to the kappa score, thus concluding it to be an important tool for diagnosing PLC injury and, therefore, an unstable spine.8 In another prospective study done by Lee et al, they reported the MRI to be 92.9%, 100%, and 85.7% sensitive in detecting injury to the supraspinous ligament, interspinous ligament, and ligamentum flavum, respectively.[3]

Our study showed substantial (FC) to almost perfect (SSL, ISL, LF) level of agreement between radiologists' MRI findings and surgeon's intraoperative findings which was similar to result of study done by Haba et al but superior to results shown by study of Shetty et al.[8,13] Various factors influence the MRI findings for the status of PLC including the time at which MRI is done after trauma and the resolution of MRI used. These differences may contribute to the difference in results of different studies.

This study also concluded that there is a positive correlation between neurological status and PLC injury as shown by spearman's correlation co-efficient which was similar to the study done by Machino et al.[14] So, those patients having PLC injuries have higher chances of neurological involvement and need to be managed operatively.

Conclusion

MRI is a reliable tool for determining the status of the posterior ligamentous complex (PLC) in spinal fractures. There is a strong agreement between MRI findings and intraoperative assessment of PLC status. MRI exhibits high sensitivity and specificity for most components of PLC, making it valuable for determining the need for surgical intervention. Additionally, MRI shows promise as screening tool for acute spine trauma. However, MRI may overestimate injury to facet capsules, suggesting the need to consider other factors such as fracture morphology, patient's age, and neurological status when planning treatment.

Limitations of Study

The study had a small sample size and was conducted at a single center only. A study with larger sample size will be required to generalize the findings.

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