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Original Research Article

Assessment of Posterior Ligamentous Complex Injury by CT and MRI Scan in AO Type-A Fractures of the Thoracolumbar Spine on Radiographs

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Abstract:

Introduction: The posterior ligamentous complex (PLC) is thought to contribute significantly to the stability of the thoracolumbar spine. PLC functions as a posterior tension band and acts as the primary stabiliser of the vertebral column. Many studies focus on plain radiographic findings and various radiological parameters were identified that were determinants of probable PLC injury. However, confusion exists when plain radiography shows no signs of posterior column involvement.

Methods: We recruited 49 Normal appearing plain radiographs cases for the study after fulfilling inclusion and exclusion criteria. Following this subsequent computed tomography (CT) scans and magnetic resonance imaging (MRI) were done and evaluated by Orthopedicians and radiologists for any signs of PLC injury. We also evaluated the correlation of PLC injury with parameters like loss of vertebral body height (LOVBH) and local kyphosis (LK) and their significance.

Results: 13/49 patients initially diagnosed as AO-A on radiographs were revised to a diagnosis of AO-B on CT scan. 22/49 patients diagnosed as AO-A on radiographs were revised to a diagnosis of AO-B on MRI scans. This included 13 cases where a CT scan also showed posterior column injury and 9 cases where even a CT scan did not show evidence of posterior column injury. Using the Chi-square test we found that there was a statistically significant difference between CT scan and MRI in identifying PLC injury ($p<0.001$). we found a significant correlation between local kyphosis (LK) and PLC injury in patients having a kyphotic angle of >20° and it was statistically significant by the Chi-Square test ($p<0.05$), however for loss of vertebral body height (LOVBH), it was statistically non-significant.

Conclusion: In a setting of normal-appearing plain radiographs, we noted to have missed 44.9% (22/49) of cases of PLC injury in AO type A fractures. Local kyphosis was significantly correlated with PLC injury but loss of vertebral body height was not.

Keywords: Posterior ligamentous complex, Spine instability, Loss of vertebral body height, Supraspinous ligament, Local kyphosis.

Introduction

Spinal injuries are common injuries following road traffic accidents or fall from height. [1–4] Thoracolumbar fractures constitute 50–60 % of all spinal injuries and incidence rates for thoracolumbar fractures have been reported as 30–60/1,00,000 population.[5]

F Denis et al [6] in 1983 did a retrospective study of 412 thoracolumbar injuries and gave the concept of the three-column theory. Subsequently, the AO classification [7] of spinal injury came into vogue and was widely accepted. It classified spinal injuries as

A. Compression injuries where the posterior ligamentous complex is intact.
B. Distraction injuries where there is disruption of the posterior ligamentous complex.
C. Displacement or dislocation.

Type B and C injuries are highly unstable and require surgery while Type A injuries can be treated either by surgery or conservatively. Posterior Ligamentous Complex (PLC) is the term given to the set of ligaments that are present in the posterior column which includes the supraspinous ligament (SSL), interspinous ligament (ISL), ligamentum flavum (LF), and the capsules of the facet joints (FJC). [6] PLC functions as a posterior tension band and acts as the primary stabilizer of the vertebral column when it comes to distractive forces while it also limits flexion and rotation of the spine. [8,9]

The posterior ligamentous complex (PLC) is thought to contribute significantly to the stability of the thoracolumbar spine. [10,11] PLC injuries if missed may have a poor outcome as they may lead to progressive deformity and back pain with/without neural deterioration.

MRI is the most widely accepted radiological investigation to detect PLC injuries. [12] A CT scan can document posterior column fractures and facet joint disruption.

However, many centers in our country may lack the capability of specialised investigations such as CT and MRI and rely on only plain radiographs to treat patients with spine injuries. This would result in an unfortunate situation of missing PLC injury in some patients, which may result in long-term morbidity in these patients. The present study aims to see that how often patients with AO type A injury on radiographs have associated PLC injury on CT/MRI.

Material and Methods

The current study was conducted after approval of the institutional ethics committee and written informed consent was taken from patients for participation. It was a prospective study including patients with acute traumatic thoracolumbar fractures who visited our tertiary care centre and full-filled the inclusion/exclusion criteria.

Inclusion criteria:

Adult patients of either sex, 18-55 years of age with thoracolumbar burst fractures.

Exclusion criteria:

1. Pathological fractures (Potts spine, metastasis, etc.).
2. Patient with kyphosis or scoliosis.
3. Thoracolumbar fractures > 3 weeks old.
4. Patients with previous thoracolumbar spine surgery.
5. Patients with any contraindications to CT scanning or MRI.
6. Patients who do not give consent to participate in the study.

Recruited patients were screened with radiographs. Classification of injury into AO types on radiograph was done by three observers (one radiologist and two Orthopaedics surgeons).

Subsequently, non-contrast CT (64 slice SIEMENS SOMATOM Definition AS) and MRI (1.5T GE SIGNA Explorer) as in the normal course of the treatment were done.

The NCCT scan and MRI were evaluated to re-classify their injuries based on the presence or absence of posterior column injury and further management was planned accordingly. The incidence of cases that are misdiagnosed as type A injuries on only radiographs was calculated. We also evaluated the correlation of PLC injury with parameters like loss of vertebral body height (LOVBH) and local kyphosis (LK) and their significance.

Statistical analysis was done on SPSS v20.0. Data collected was represented as mean and standard deviation. A Chi-Square test was done to compare between the two modalities and to find the significance between the degree of kyphosis and percentage of LOVBH assessed by X-ray and CT. p-value <0.05 was taken as significant.

Results:

49 cases who fulfilled inclusion/exclusion criteria were recruited. The most frequent level was thoracolumbar (D12-L1 = 55%), followed by lumbar (L2-L5 = 30%). The mean age was 32 years and male to female ratio was 3:1 (M= 37, F= 12).

Table 1: PLC injury on CT/MRI

	Frequency	Percent
PLC injury detected on CT	13	26.5
PLC injury detected on MRI	22	44.9

PLC- posterior ligamentous complex.

13 out of 49 individuals who had been assessed as AO-A injury on radiographs were revised to AO-B injury after CT scan imaging. (Table-1) On MRI scans, 22 patients with AO-A radiographic diagnosis were recategorized to AO-B (Table 2). This comprised 9 cases in which even a CT scan failed to reveal any evidence of posterior column injury. We observed that there was a statistically significant difference between CT scan and MRI in terms of detecting PLC injury using the Chi-square test (p 0.001).

Table 2: Comparison of CT and MRI with PLC injury

		MRI s/o PLC injury		Total	Chi-square value	p-value
		N (n)	Y (n)			
CT S/O PLC injury	N (n)	27	9	36	21.716	<0.001
	Y (n)	0	13	13		
Total		**27**	**22**	**49**		

PLC- posterior ligamentous complex.

CT scan had a sensitivity of 59% and a specificity of 100% in diagnosing PLC injury as per the above data as compared to MRI. (Table 3) In patients with a kyphotic angle of greater than 20°, we found a statistically significant correlation with PLC injury on MRI (p<.05). (Table 3)

Table 3: Comparison of kyphosis in CT/ X-ray and MRI with PLC injury

		MRI s/o PLC injury		Chi-square value	p-value
		N	Y		
Degree of kyphosis on X-ray and CT scan (degree)	≤20°	16/22 (73%)	6/22 (27%)	5.01	.025
	>20°	11/27 (41%)	16/27 (59%)		
Total		27/49	22/49		

PLC- posterior ligamentous complex.

The incidence of PLC injury was 59% in patients having a kyphotic angle of >20° while it was only 27% in patients with a kyphotic angle of <20°. For loss of vertebral body height (LOVBH), there was no correlation (p> 0.05) between X-ray and CT scan to show PLC injury. (Table 4)

Table 4: Comparison of LOVBH in CT/X-ray and MRI with PLC injury

		MRI s/o PLC injury		Chi-square value	p-value
		No	Yes		
LOVBH on Xray and CT scan	≤25%	6/8 (75%)	2/8 (25%)	1.59	0.44
	26-50%	15/30 (50%)	15/30 (50%)		
	>50%	5/11 (45.5%)	6/11 (54.5%)		
Total		26/49	23/49		

PLC- posterior ligamentous complex, LOVBH- loss of vertebral body height.

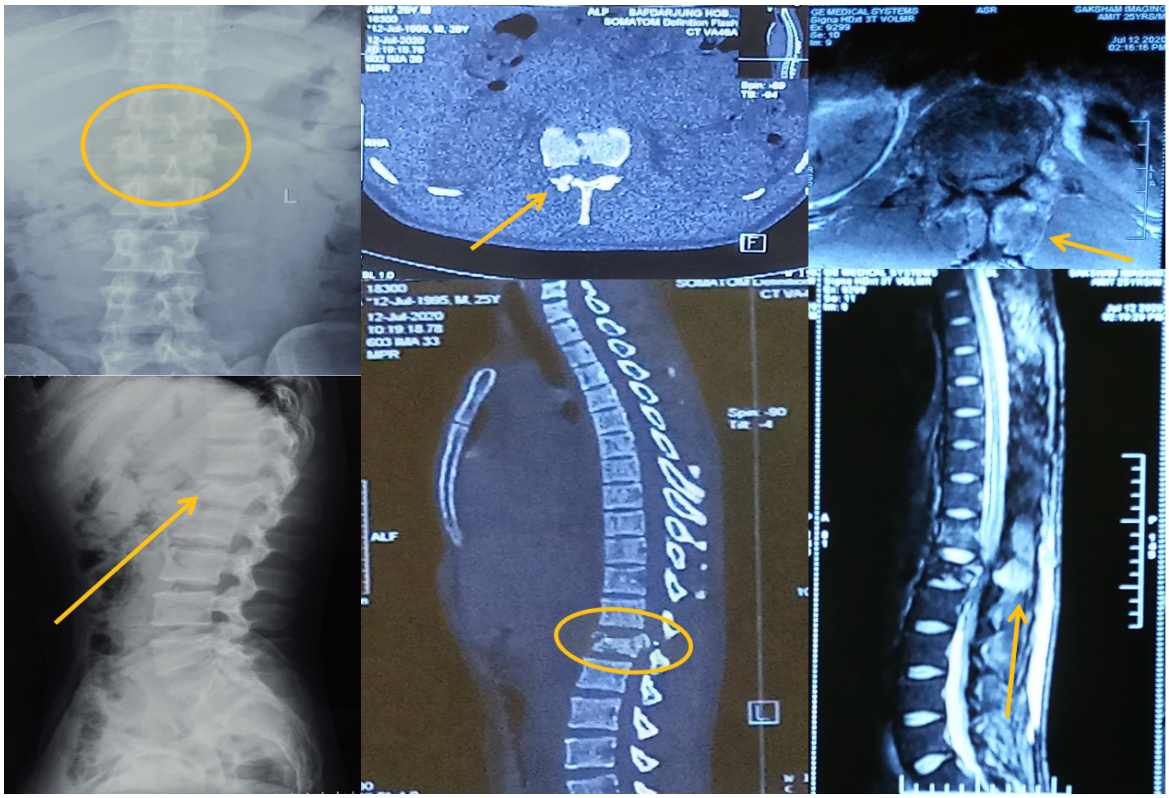

Figure 1: (Case 1)A 24/M with traumatic spine injury showing compression fracture of L1 vertebrae (LOVBH= 44%, LK=25°) showing no any evidence of PLC injury on plain radiograph but on subsequent CT and MRI shows signs of PLC injury.

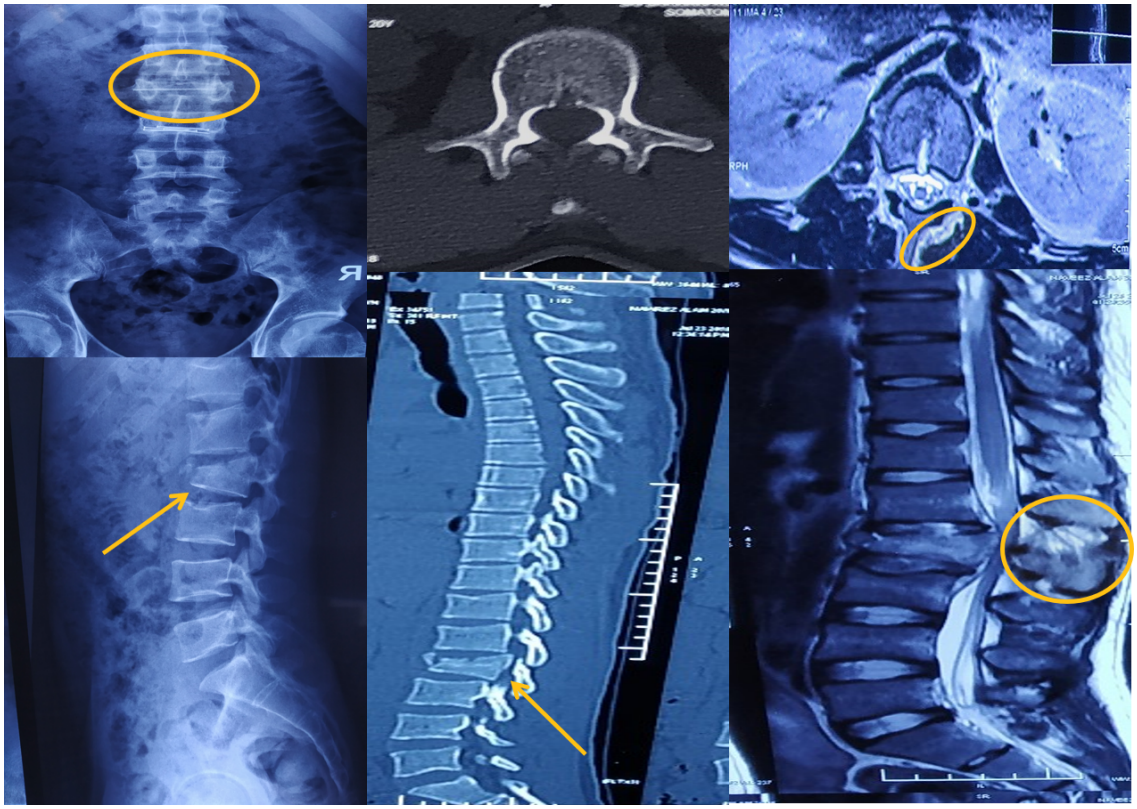

Figure 2: (Case 2): - A 20/M with L2 Burst fracture (LOVBH= 40%, LK= 12°). On plain radiographs and CT scan had no signs of PLC injury but on subsequent MRI its shows PLC injury on T2-weighted images

Discussion

F Holdsworth et al [13] had a significant impact on understanding thoracolumbar injuries and established the two-column theory. Later on, F Denis et al [6] (1983) introduce the middle column concept.

The AO classification is the most commonly accepted classification that takes into account the injury mechanism and focuses in particular on the PLC injury. However, due to the ligamentous nature of the PLC, it is frequently challenging to visualize the precise extent of PLC involvement without an MRI, making it challenging to appropriately categorize the damage based solely on X-rays or even with a CT scan.

PLC injuries, if not treated, can result in spinal instability. Smith et al [4] have also noted that PLC damage is an important factor to consider in thoracolumbar fractures. PLC is relatively avascular with poor potential to heal.

In 1995 Petersilge [14] et al evaluated a relationship between the disruption of ligaments (supraspinatus) and radiographic appearances. Only 33% of cases with ligament injury presented with radiographic findings. In 2006, Vaccaro et al. [15] reported that there is no single image criterion threshold for determining PLC disruption. The most extensively used criteria were diastasis of the facets on CT scans and vertebral translation and opening of the interspinous gap in radiographs. In 2007 Y Lee et al [16] found other radiographic parameters (Table 5) that may be suggestive of PLC injuries in a normal-appearing plain radiograph based on CT and MRI scans.

Table 5: CT and MRI criteria suggestive of PLC injury

Key	Criteria
A	Posterior edema (high signal intensity) in the region of PLC elements on T2 STIR or FAT SAT sagittal MRI
B	Diastasis of the facet joints on CT
C	Diastasis of the facet joints on T2 axial MRI
D	Focal posterior tenderness on examination
E	Disrupted PLC component (i.e. LF, ISL, SSL, facet capsules) on T1 sagittal MRI
F	Other: Fascial degloving lesion at the site of injury
G	Other: Disrupted PLC component (i.e. LF, ISL, SSL, facet capsules) on proton MRI sequence

(Adapted from Schweitzer KM, Vaccaro AR, Harrop JS, Hurlbert J, Carrino JA, Rechtine GR, et al. Interrater reliability of identifying indicators of posterior ligamentous complex disruption when plain films are indeterminate in thoracolumbar injuries. J Orthop Sci. 2007 Sep;12(5):437–42.)

The most extensively used parameters for using MRI imaging to predict PLC injury were provided by Pizones et al in 2012.[17] In a related study in 2012, he also commented on the establishment of imaging criteria to define whether the posterior ligamentous complex injury is competent or incompetent. They concluded that ISL with facet diastasis alone is not sufficient for PLC to be incompetent. SSL rupture added to the above leads to incompetency of PLC. [18]

Due to the extremely high collagen content, the supraspinous ligament (SSL) and interspinous ligament (ISL) appear dark on T1 and T2 sequences [19]. The 80% elastin content of the ligamentum flavum (LF), on the other hand, results in an intermediate signal appearance. On T1- and T2-weighted sequences, SSL appears as a solid black stripe; as a result, any injury is perceived as a break in the same. [20] Based on inclusion/exclusion criteria, a total of 49 cases were recruited for this study. The age group with the highest prevalence was 21 to 30 years old (36.7%). The male-to-female ratio was 3:1 roughly. Khurjekar K et al [21] showed a male predominance of 8:1, in a study of 92 cases.

In 49 cases that were initially identified as AO type A injuries based on the evalution of the radiographs, further investigation by CT and MRI found that 22 (44.9%) of them actually had some component of PLC injury and were, thus, AO type B injuries. Terk et al [22] concluded similar results of 53% misdiagnosis incidence. Similarly, Schnake et al [23] in 2008 observed 41.9% of type B injuries were not recognized. With the aid of CT scans alone, we were able to identify 13 (13/49, 26.5%) instances as having PLC injuries while MRI could pick 22/49 cases with PLC injury. In 9/49 cases, where PLC injury could only be observed on MRI, CT was unable to identify it, giving the test diagnostic accuracy of 81.6% (40/49) for CT scan. Y Lee et al[16], C Blackmore et al[24], H Gamal et al [25] also concluded that CT is a better imaging modality than plain radiograph but inferior to MRI.

MRI is the gold standard to detect PLC injury as documented by Haba et al[26], LS Medina[27]. Lee et al[12] reported on the reliability of MRI to identify PLC injury and concluded that MRI is a highly sensitive, specific, and accurate investigation for identifying PLC Injury. In current study, 22 patients were found to be AO type B injuries, giving a misdiagnosis rate of 44.9% (22/49). We evaluated the association of local kyphosis (LK) with PLC injury in patients with LK ≤20° and LK >20° as many previous authors have done[17,18,28–30] and our data revealed a significant association between LK >20° and PLC injury with a p-value of 0.025. This finding is consistent with studies by Rajasekaran et al [28], Hiyama et al [29] and Chen et al [30], but Radcliff et al [31] found LK to be an unreliable marker for PLC injury.

Loss of vertebral body height (LOVBH) was calculated using X-rays and CT images and tested for a possible correlation with PLC injury to determine its predictive value. However, in our study no direct relationship was discovered for either of them (p-value - 0.44). This is consistent with previous reports by Rajasekaran et al [28], Radcliff et al [31], and Hiyama et al [29]. However, studies by some authors, such as Chen et al [30] and Khurana et al [32] concluded that vertebral height loss has a positive predictive value.

Conclusion

Plain radiographs were found to have missed 44.9% of cases of PLC injury in AO type A fractures when MRI-proven cases were used as the gold standard.

As PLC is important in respect to spinal instability it is important to accurately categorise these injuries, as missed injuries leads to bad prognosis. CT and MRI are better imaging modalities and have less chances of missing PLC. A local kyphosis angle of more than 20 degrees was found to be significantly related to the presence of a posterior ligamentous complex injury.

The loss of vertebral body height was found to be unrelated to the injury to the posterior ligamentous complex. Given the small number of cases in this study, we recommend larger sample size studies in the future to more accurately correlate specific findings with PLC involvement.

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