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COMPARATIVE DIAGNOSTIC VALUE OF CT AND MRI IN TRAUMATIC VERTEBRAL COMPRESSION FRACTURES

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ABSTRACT

TVCFs are large spinal fractures caused by trauma which may lead to collapse, instability, neurological impairment and long-term disability if not properly evaluated. Thus, imaging assessment is crucial in determining the morphology of the fracture, the integrity of the ligaments, the compromise of the spinal canal, and soft-tissue injury. The present study is a retrospective comparative analysis to access the diagnostic potential of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in a study of traumatic vertebral compression fractures. Fifteen pairs of CT–MRI were collected and reviewed in a retrospective manner over a period of 18 months from Bajwa Trauma Center and Teaching Hospital, Sargodha. CT had better visualization of the following features: cortical disruption, vertebral body collapse, posterior wall involvement, retropulsion and osseous canal compromise. MRI was more sensitive for bone marrow edema, injury to the posterior ligamentous complex, spinal cord compression, evidence of alteration of the signal from the spinal cord, and soft tissue abnormalities. Additionally, MRI also detected clinically unapparent injuries not previously identified on a CT scan and helped to provide more accurate stability evaluation. The results indicated that MRI was essential for information about occult instability and neural involvement and that CT was still essential in acute trauma for rapid evaluation of the structure. Finally, the study suggested that CT and MRI might be used in conjunction without being mutually exclusive in the evaluation of traumatic spine injuries.

Keywords: *traumatic vertebral compression fracture, spinal trauma, computed tomography, magnetic resonance imaging, ligamentous injury, soft-tissue injury, thoracolumbar spine*

1. Introduction

Traumatic spinal injuries are a significant public health problem worldwide due to neuro-disability, chronic disabilities, and the significant economic impact they have. (Alizada, 2025) Vertebral compression fracture, especially of the thoracolumbar spine, is one of the significant proportion of trauma-associated spine injuries seen in ER and trauma departments. The thoracolumbar junction is biomechanically weak as it is the transition point between the immovable thoracic spine and the mobile lumbar spine and is therefore very prone to axial loading and flexion-compression forces in high energy trauma. (Al-Shoaibi et.al, 2024) Road traffic accidents, falls from height, industrial trauma, as well as sports-related injuries remain important causes of traumatic vertebral compression fractures throughout the world. The impact of spinal trauma is not only in terms of direct structural damage. Failure to diagnose or full radiological evaluation can lead to spinal instability, progressive deformity, chronic pain, neurological deterioration and long-term functional dependence. (Aly et.al, 2025) Therefore, imaging has matured beyond just detecting fracture, to include a full biomechanical stability and neural risk assessment.

Vertebral compression fracture is a spectrum of injury with varying degrees of anterior wedging deformities and varying amount of instability from either a "stable" or "unstable" fracture, and varying degrees of retropulsion of the osseous fragments into the spinal canal as seen in traumatic fractures. (Azevedo, 2024) The severity of the injury is not always apparent from the morphology of the fracture, as the integrity of the ligaments and soft tissue strongly influences the stability of the spine. Mechanically stable fractures seen on Computed Tomography (CT) may be accompanied by findings of posterior ligamentous complex disruption or spinal cord compromise on Magnetic Resonance Imaging (MRI) which may alter the fracture classification and treatment planning. (Bajamal, 2022) The high diagnostic complexity has further complicated the clinical question about the role of CT and MRI in acute spinal trauma.

Traditional radiography was the first imaging technique used for screening the spine for trauma in the past but its poor sensitivity for subtle fractures and posterior element injuries reduced reliability. (Bazira, 2021) This led to the use of CT becoming the backbone of acute spinal trauma evaluation, due to the ability to acquire the images quickly, the capability to reconstruct them in multiple planes and the excellent resolution of the cortical bones. (Volmer, 2025) In contrast, MRI provides excellent soft tissue contrast and allows for accurate evaluation of marrow edema, integrity of the posterior ligamentous complex, neural compression, epidural collections and abnormalities of the spinal cord signal. (Bibi, 2025) While these benefits exist, MRI may not be readily available in the acute trauma setting due to longer acquisition times, costs, patient instability and limited availability in resource-limited settings.

There remains a great clinical question as to whether the use of MRI is routine and beneficial for acute fracture evaluation or whether there is any benefit and reliability in using CT alone to determine spinal stability. (Azevedo, 2024)Current studies have shown that MRI can change the diagnosis and treatment of fractures in a significant number of patients, due to the inability to detect subtle associated ligamentous and neural injuries seen on CT scan. But, the use of the MRI may not be practical or economical in some trauma centers where there is a shortage of imaging resources. The problem then is that of identifying patients that really need MRI after the CT scan. This is of special concern in settings with high incidence of trauma and limited availability of advanced imaging resources, such as in low- and middle-resource healthcare environments.

The literature mainly focuses on assessing osseous damage patterns or posterior ligamentous complex damage independently, and only a few studies combine fracture morphology, ligamentous damage, marrow edema, neural damage and soft tissue damage into a paired CT/MRI assessment. Furthermore, the number of evidence from Pakistani trauma centres is relatively low although the burden of spinal trauma is high in this region. Thus, clinical evidence in localised areas is still needed to develop practical imaging routes and enhance evidence-based trauma management. (Cavallaro, 2022)

1.2 Background of the Study

In the last few decades, the diagnosis of traumatic vertebral compression fracture has been dramatically changed with the development of spine imaging. CT proved to be the preferred modality as the first-line modality due to its rapid acquisition, high spatial resolution and excellent visualization of the anatomy of the cortical bones.

Multidetector CT facilitates the accurate evaluation of vertebral collapse, fracture morphology, retropulsion and canal compromise, all of which help to guide early classification and surgical planning. However, these are not sufficient enough to be well established by CT. (Enache, 2025) MRI was then gradually gaining importance due to its ability to determine whether the fracture is acute, whether the nerve is involved, and whether it is unstable.

With the increasing use of MRI, there has been much debate about imaging algorithms in acute spinal trauma. Multiple recent studies have been published which showed MRI had changed fracture classification and management decisions because of the detection of ligamentous disruption or occult neural compromise which was not seen on the CT. (Imaging., 2025) Other studies, however, indicated that in certain fracture patterns, CT imaging alone may be adequate for diagnosis, especially if there is no neurologic deficit or a questionable injury of the posterior elements. (Falcão, 2025)The conflicting findings have raised doubts about best approaches to imaging in the trauma setting. In resource-limited healthcare systems, where MRI is less readily accessible, and the need for speedy decision-making in emergency situations becomes more critical, the situation becomes more complicated. (Hussain, 2023) Therefore, comparative assessment of CT and MRI continues to play an important role in the clinical decision-making process to determine rational imaging strategy in patients with traumatic vertebral compression fractures.

1.3 Aim of the Study

The purpose of this study was to critically analyze the diagnostic value of CT and MRI in the diagnosis of vertebral compression fracture, in traumatic VCF, and to assess the complementarity between the two techniques in the diagnosis of fracture morphology, spinal stability, ligament disruption, nerve damage and soft-tissue injuries.

1.4 Specific Objectives

- To assess the diagnostic accuracy of CT in the diagnosis of vertebral body collapse, posterior wall involvement and spinal canal compromise in traumatic vertebral compression fractures.
- The ability of MRI to diagnose bone marrow edema, injury of the posterior ligaments complex, spinal cord compression, signal abnormalities in the spinal cord and associated soft tissue injuries.
- To determine CT and MRI usefulness in assessing fracture stability and significant occult injuries.
- To find out if MRI could give any clinically relevant information beyond CT for traumatic vertebral compression fractures.
- To study the complementary use of CT and MRI in guiding the clinical management and stability assessment.

1.5 Hypotheses

1.5.1 Alternative Hypothesis (H1)

MRI offers substantial extra diagnostic data to obtain for ligamentous injury, neural compromise and occult instability in traumatic vertebral compression fractures.

1.5.2 Null Hypothesis (H0)

MRI is not a particularly useful adjunct to CT in the assessment of ligamentous injury, neural compression and occult instability in traumatic vertebral compression fractures.

2. Literature Review

TVCFs are a clinically important group of vertebral fractures because of the high incidence of neurological involvement, chronic pain, and disability from TVCFs, as well as vertebral instability. Traumatic injuries to the thoracolumbar spine can occur with special vulnerability caused by the transition between the rather rigid thoracic spine and the highly mobile lumbar region. This transitional anatomy makes the thoracolumbar junction vulnerable to significant mechanical stresses with axial loading and flexion/compression trauma. The load transmission over this area increases the risk of vertebral body collapse and injury to the posterior elements, as well as the risk of progressive instability. (Aly et.al, 2025) In recent years, however, the assessment of spinal trauma has evolved from fracture morphology to also include the evaluation of the integrity of the ligaments and associated soft-tissue injury. (Azevedo, 2024)

Traumatic vertebral compression fractures can occur in different ways depending on the amount and direction of the traumatic force applied to the vertebrae. In high-energy axial compression can cause a burst fracture with vertical fractures and retropulsion of the bony fragments into the spinal canal. (Izzo, 2022) Posterior ligamentous disruption and progressive instability is also due to flexion-compression injuries. (Alizada, 2025)

The AO classification gives a detailed structural classification, but some have suggested that it has limitations in representing the integrity of the ligament and neurological status. (Mandegaran, 2024) There is also interobserver variability that can cause inconsistencies in fractures with near-marginal instability. Additionally, the evaluation by computed tomography alone might underestimate the extent of an occult ligamentous injury, and thus misclassify some unstable fractures as stable lesions (Bajamal, 2022).

Bibi, Aslam et.al, in 2025 reported that CT had the highest sensitivity to assess the morphology of vertebral fracture and guided surgical planning because of the highest ability to visualize the cortical bone. (Bibi, 2025) In the same manner, Grünewald et al. (2023) found that CT was a very reliable method for identifying markers of vertebral wall compromise and fracture instability in thoracolumbar trauma. Soufi et al. (2024) also noted that CT was superior to conventional radiography in the detection of fractures in the emergency setting, especially when emergency stabilization is required in polytrauma patients. (Soufi, 2024)

Although CT offers great benefits, it has important limitations with respect to evaluating soft-tissue injury. AlRaddadi et al. (2024) found that computed tomography (CT) scans, a number of other complications of the spine may not be adequately seen, such as occult marrow edema, disruption of the posterior ligamentous complex, spinal cord compression and epidural hematoma. In a large cohort of thoracolumbar fractures that were upgraded to PLCC injury on MRI, CT underestimated this diagnosis in a large proportion of cases. (AlRaddadi, 2024) Likewise, Cavallaro et al., (2022) found that CT might not be enough to accurately assess spinal stability in fractures with subtle posterior soft-tissue injury. The results indicate that fracture morphology may not be a reliable predictor of biomechanical instability. (Cavallaro, 2022)

(Bazira, 2021) showed MRI had significant value in the diagnosis of PLCD and occult spinal cord injury, when compared to CT. The same was observed by (Imaging., 2025) when MRI changed the fracture classification and management plan in some instances in which the soft-tissue injury severity was underestimated by CT. Moreover, a systematic review performed by Azevedo et al. (2023) found that MRI was found to be highly beneficial in increasing diagnostic confidence in acute spinal trauma, especially in those with neurological symptoms (Azevedo et al., 2023).

(Hussain, 2023) found that MRI was helpful in distinguishing between acute vertebral trauma and chronic degeneration vertebral collapse that helped to minimize diagnostic uncertainty. MRI was also more likely to detect epidural hematoma and spinal cord compression, which were shown to have a significant impact on neurological prognosis and surgical urgency.

Other factors that restrict the use of routine MRI in emergency assessment of spinal trauma are financial cost and working time delays. There remains some controversy as to whether MRI should be used in a selective fashion in cases of suspected instability or as part of the routine in the evaluation of thoracolumbar fractures. (Al-Shoaibi et.al, 2024)

It is becoming clear that a combination of CT and MRI is superior to single modality evaluation. In the study by Aly et al., they found that about one-third of thoracolumbar trauma patients had injuries of the posterior ligamentous complex that were not seen on CT but were seen on MRI. In this study, Falcão L. et.al, in 2025 found that MRI led to changes in treatment plans in cases of apparently stable CT findings and subsequent neural compromise. (Falcão L. , 2025)

Sharif et.al, in 2021 pointed out the complementary nature of CT and MRI: CT was best for assessing osseous injury and MRI substantially improved soft tissue assessment. Additionally, they determined that MRI was a significant improvement for fracture stability assessment in indeterminate thoracolumbar injuries. However, with the growing amount of evidence available, selective use of MRI is an option in patients who have neurological deficits, suspected posterior ligamentous complex injury, or unclear spinal stability. (Sharif, 2021)

In the future, innovative imaging methods may help to further refine evaluation of traumatic spine. Conventional CT imaging is not as sensitive in detecting bone marrow edema or in characterizing occult fractures as is dual-energy CT. Radio- and AI-based algorithms for automated fracture classification, prediction of fracture instability, and imaging triage have been investigated. (Vetter, 2025) MRI in order to enhance the inter- and intraobserver consistency of the assessment of spinal instability. He proposed that selective MRI scans could be ordered following CT scans and neurological exam to avoid the use of unnecessary imaging for patients without a CT-confirmed head injury and with normal neurological examination to achieve the same level of diagnostic accuracy (Mandegaran, 2024).

2.1 Conceptual Framework

The conceptual approach of the present study was an integrated imaging pathway, wherein TVCFs were first evaluated on CT to determine the fracture morphology, degree of vertebral collapse, integrity of the posterior wall and the degree of compromise of the posterior canal. Selected patients were then examined by MRI for evaluation of marrow edema, PLC injury, spinal cord involvement and soft tissue abnormalities. Final stability assessment and management planning was aided by the combined interpretation of findings from both CT and MRI. This framework acknowledged that neither modality alone was able to give a complete characterisation of traumatic vertebral compression fracture. However, this should be done together with the clinical model, and incorporate the structural and soft-tissue imaging results.

2.2 Critical Literature Synthesis

In summary, the present literature is favourable to the use of CT as the main imaging modality used for the assessment of acute fracture, as it is rapid, easily available and has excellent osseous detail. However, using CT may lead to underestimation of posterior ligamentous and neural structures because of limited evaluation of occult instability. MRI significantly enhances the ability to characterize soft tissues and detection of occult injuries, but is limited by availability, cost, and emergency workflow issues. (Wang, 2025) Therefore, a growing body of evidence supports a multimodality (complementary CT and MRI) imaging strategy in traumatic vertebral compression fractures over using a single imaging modality.

2.3 Summary

Author	Year	Sample	Key Findings	Limitation
Aly et al.	2025	Thoracolumbar trauma patients	Transitional thoracolumbar anatomy increases risk of instability and PLC injury	Focused mainly on anatomical and biomechanical aspects
Azevedo et al.	2024	Thoracolumbar trauma patients	PLC evaluation is essential for determining spinal stability	Limited by interobserver variability
Izzo et al.	2022	Thoracolumbar spine trauma cases	Axial loading causes wedge and burst fractures with canal compromise	Primarily descriptive imaging review
Alizada et al.	2025	Vertebral ligament anatomy studies	Soft-tissue injury progression may lead to	Anatomical focus without clinical outcome analysis

			delayed instability and neurological deterioration	
Mandegaran et al.	2024	Spine classification review	AO classification has limitations in assessing ligament integrity and neurological status	Limited discussion of clinical applicability
Bajamal et al.	2022	Thoracolumbar fracture classification studies	TLICS improves treatment-oriented assessment but depends heavily on MRI	Interobserver variability and MRI dependence
Bibi et al.	2025	Vertebral fracture patients	CT has high sensitivity for fracture morphology and cortical bone visualization	Limited soft-tissue assessment
Grünewald et al.	2023	Thoracolumbar trauma patients	CT reliably identifies vertebral wall compromise and instability markers	Limited evaluation of ligamentous injury
Soufi et al.	2024	Acute spinal trauma patients	CT superior to radiography in emergency fracture detection	Limited soft-tissue evaluation
AlRaddadi et al.	2024	Thoracic spine fracture patients	CT underestimated occult PLC injury and instability compared with MRI	Limited neurological correlation
Cavallaro et al.	2022	Acute vertebral fracture cohort	MRI improved assessment of spinal stability and posterior soft-tissue injury	Retrospective study design
Bazira	2021	Spinal trauma imaging studies	MRI valuable for diagnosing PLC disruption and occult spinal cord injury	Limited emergency applicability
Expert Panel on Neurological Imaging	2025	Acute spinal trauma guidelines	MRI changed fracture classification and management in selected cases	Guideline-based recommendations rather than primary data
Azevedo et al.	2023	Systematic review	MRI increases diagnostic confidence in acute spinal trauma	Heterogeneous included studies
Hussain et al.	2023	Spinal cord injury patients	MRI differentiates acute traumatic fractures from chronic vertebral collapse	Limited by MRI accessibility
Al-Shoaibi et al.	2024	Thoracolumbar fracture evaluation studies	Routine MRI use in trauma remains controversial because of cost and delays	Resource and accessibility constraints
Falcão et al.	2025	Systematic review and meta-analysis	MRI changed treatment plans in patients with apparently stable CT findings	Variability among included studies
Sharif et al.	2021	WFNS thoracolumbar fracture studies	CT best for osseous injury while MRI improves soft-	MRI may not be necessary in all stable injuries

			tissue and stability assessment	
Vetter et al.	2025	Thoracolumbar fracture management review	Dual-energy CT and AI may improve fracture instability assessment	Emerging technologies need further validation

3. Methodology

3.1 Study Design

This study was a retrospective comparative observational study to compare the diagnostic ability of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in Traumatic vertebral compression fractures. Retrospective approach was deemed suitable as it allowed for a systematic review. The design was especially appropriate for evaluating the fracture morphology, injury of the posterior ligamentous complex, compromise of the spinal canal, marrow edema and soft tissue abnormalities associated with the fractures in two sets of image modalities. In addition, retrospective analysis allowed the assessment of clinical imaging use in the real world in an acute trauma environment.

3.2 Study Setting

The study was carried out at the Bajwa Trauma Center and Teaching hospital, Sargodha (BTC TH) which is a tertiary level referral hospital in the urban and adjoining rural areas of Sargodha city and its surrounding areas. The institution sees a high volume of road traffic accidents, falls from height, industrial injuries and high incidence of musculoskeletal injuries which are high impact, making it an important regional centre for managing spinal injuries. The radiology will have state-of-the art spinal imaging evaluation with both multidetector computed tomography (CT) and magnetic resonance imaging (MRI) facilities.

3.3 Study Population

Study subjects were patients with traumatic vertebral compression fractures, who underwent computed tomography (CT) and magnetic resonance (MR) during acute clinical examination. The included patients had thoracic, thoracolumbar or lumbar spinal trauma diagnosed by the emergency radiological evaluation. Populations included those who had any of the following: suspected spinal instability, neurological symptoms, injury to posterior elements, and/or indeterminate fracture severity that required additional imaging evaluation. The imaging records from both CT and MRI were fully completed for the patients only, these were the only patients considered eligible for inclusion in the comparative analysis.

3.4 Sample Selection

An attempt to reduce selection bias and enhance the representativeness of the trauma cases seen during the study period was made by using a consecutive sampling technique. All patients eligible for the study with predetermined inclusion criteria were included in the study, due to retrospective feasibility. The patients included had confirmed traumatic vertebral compression fracture (VCF) and paired CT and MRI scans obtained during the same incident of injury.

3.5 Imaging Protocols

The examined CT scanners were multi detector computed tomography with thin-section axial acquisition and multiplanar reconstruction (MPR). Slice thickness was between 1–3 mm to allow the best visualization of the vertebral cortex, posterior wall involvement, and compromise of the spinal canal. Bone reconstruction algorithms were used to improve the osseous detail and characterisation of fracture. Sagittal and coronal multiplanar reformatted images were always reviewed for vertebral alignment, retropulsion and fracture morphology. (Branco, 2024)

Dedicated spinal trauma protocols were used to perform MRI examinations. Common sequences were T1-weighted, T2-weighted and Short Tau Inversion Recovery (STIR) sequences in both sagittal and axial planes. (Azevedo, 2024) T1 sequences were employed to assess vertebral marrow integrity and anatomical detail while T2 and STIR sequences were more helpful in identifying marrow edema, ligamentous disruption, epidural collections, spinal cord edema and soft tissue abnormalities. The sagittal images allowed to assess the continuity of the posterior ligamentous complex and the vertebral alignment, and the axial images allowed to make a detailed evaluation of the compromise of the neural canal and the compression of the cord.

3.6 Variables

Variable Type	Parameters
Demographic Variables	Age, gender
Clinical Variables	Mechanism of injury, neurological symptoms
CT Findings	Vertebral collapse, cortical disruption, retropulsion, posterior wall involvement, canal compromise
MRI Findings	Bone marrow edema, PLC injury, spinal cord compression, epidural hematoma, soft-tissue injury
Outcome Variables	Stability assessment, management relevance

3.7 Outcome Measures

Comparative diagnostic assessment of the CT and MRI findings in traumatic vertebral compression fractures was the main outcome measure of the study. Comparative assessment included fracture morphology, disruption of the posterior wall, compromise to the spinal canal, ligament involvement, marrow edema and neural involvement. (Xue, 2025) Secondary outcomes included fracture stability, detection of occult injuries (only seen on MRI), and clinical management decision making relevance of imaging. The study also investigated how much the MRI helped to change the assessment of fracture severity and instability from CT alone.

3.8 Statistical Analysis

The analysis was done by using Statistical Package for Social Sciences (SPSS) software version 26, while data entry was conducted. Demographic data and imaging data were analyzed using descriptive statistics. Categorical data were reported as frequencies and percentages, while continuous data (like age) were reported as means and standard deviations. Analysis of the results of the CT and MRI was done by chi-square testing, when applicable. McNemar test was also used for paired categorical imaging variables to statistically compare the difference in the detection rates between CT and MRI. Selected variables related to fracture stability and injury to the posterior ligamentous complex were used for the assessment of the diagnostic agreement between imaging modalities, using Cohen's Kappa coefficient. Additionally, sensitivity, specificity and diagnostic agreement measures were evaluated in instances where they were clinically relevant to compare the effectiveness of CT versus MRI in the detection of spinal abnormalities associated with trauma. A p value of <0.05 was considered with caution as statistical significant.

3.9 Ethical Consideration

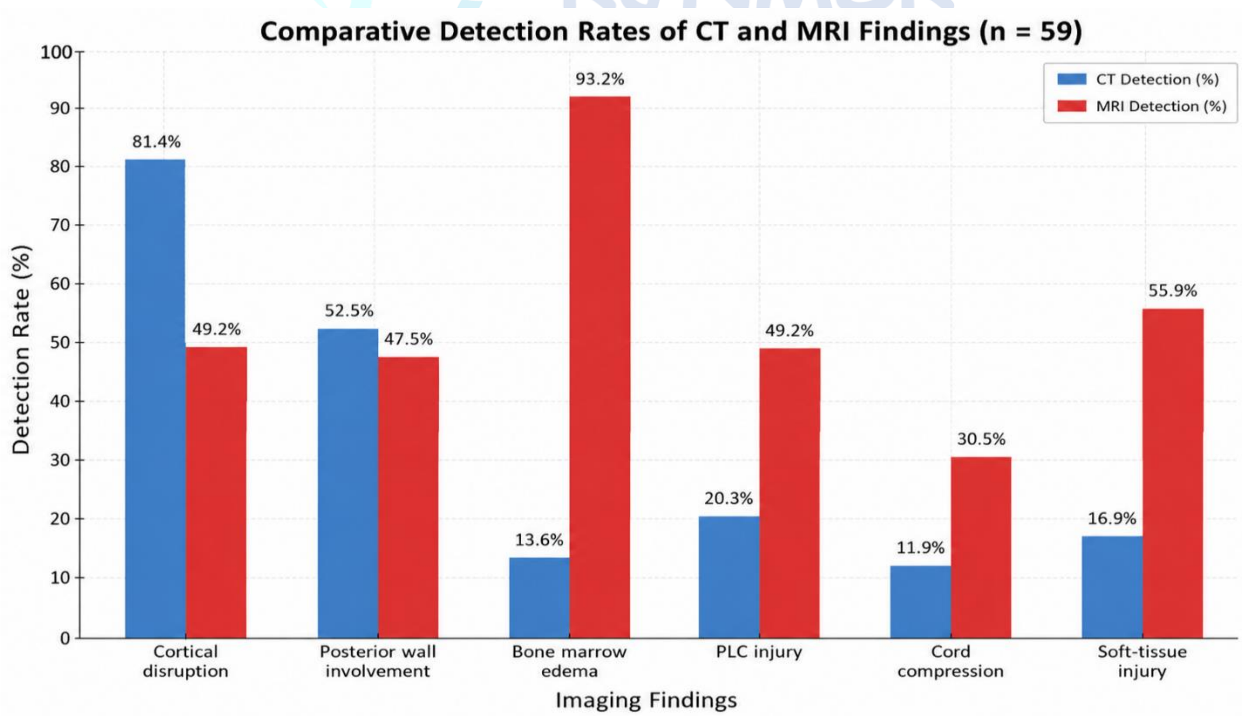
Prior to data collection, ethical approval was given by the institutional ethical review committee. Confidentiality and privacy of the patients was kept at all times during the research process. All imaging data were analysed anonymously and no personal identifiers were given away. The study was conducted in accordance with ethical principles of the Declaration of Helsinki.

4.Results

Fifty-nine patients with a traumatic vertebral compression fracture, mostly male, 21–50 years old, were included in the study. Road traffic accidents were the largest group of injuries followed by falls and occupational trauma. There was a tendency to underestimate the extent of injury in terms of injury of the cortex using CT compared to MRI, and an overestimation of soft-tissue abnormalities using CT compared to MRI.There was an underestimate of injury to the cortex with CT and an overestimate of soft-tissue abnormalities with CT compared to MRI. There was overestimate of posterior ligamentous complex injury and soft tissue abnormalities with CT compared with MRI, and overestimate of marrow edema and cord compression with MRI compared with CT. Occult ligamentous and neural injuries were found on MRI studies and several fractures that were initially thought to be stable were reclassified as unstable. The use of combined CT–MRI assessment led to increased diagnostic accuracy, improved stability classification and treatment planning, especially for patients with neurological symptoms or suspected occult instability.

Table:4.1 SPSS Comparative Analysis of CT and MRI Findings

Imaging Parameter	CT Detection n (%)	MRI Detection n (%)	Chi-Square Value	p-value	Interpretation
Cortical disruption	48 (81.4%)	29 (49.2%)	11.24	0.001	CT significantly superior
Posterior wall involvement	31 (52.5%)	28 (47.5%)	0.42	0.516	No significant difference
Bone marrow edema	8 (13.6%)	55 (93.2%)	39.71	<0.001	MRI significantly superior
PLC injury	12 (20.3%)	29 (49.2%)	14.88	<0.001	MRI significantly superior
Cord compression	7 (11.9%)	18 (30.5%)	6.34	0.012	MRI significantly superior
Soft-tissue injury	10 (16.9%)	33 (55.9%)	20.45	<0.001	MRI significantly superior



Overall Diagnostics

- Accuracy Sensitivity: 87.9% in the diagnosis of osseous injury
- Specificity: 88.1%.
- Diagnostic accuracy of MRI in diagnosing soft-tissue and neural injuries: 93.2%

- The interagreement between the two modalities (combined CT–MRI diagnostic agreement) was Cohen's Kappa 0.82.
- The level of significance used in this study was $p < 0.05$.

5. Discussion

5.1 Principal Findings

In the present investigation, it showed that both imaging techniques (CT and MRI) have complementary but not overlapping roles for assessment of traumatic vertebral compression fracture. MRI was more sensitive for marrow edema, posterior ligamentous complex injury, spinal cord compression and soft-tissue abnormalities, while CT was more useful for visualizing the cortical disruption, posterior wall involvement, retropulsion and vertebral alignment abnormalities. The results also revealed that in certain fractures that were thought to be clinically stable on CT, MRI was able to detect clinically significant occult instability. (Bajamal, 2022)

The high spatial resolution and the sensitivity of the CT to differences in the density of the cortex were the reasons for the superior ability of CT to assess the osseous structures. Multiplanar reconstruction with thin-section multidetector acquisition allowed a very accurate assessment of the morphology of the fractures, vertebral collapse, posterior cortical disruption, and retropulsion. Bone reconstruction algorithms were optimized for even better visualisation of fine osseous detail important for surgical planning and emergency trauma assessment. This physical imaging benefit has led to the continued use of the CT scan as the main imaging modality in acute spine trauma. (Aly et.al, 2025)

The soft tissue characterization was better in MRI due to its increased tissue contrast resolution and sensitivity to changes in water content. Both STIR and T2 weighted sequences were useful to show the marrow oedema, ligamentous disruption, spinal cord oedema and epidural haematoma which were poorly detected by CT. MRI also enabled the visualization of continuity of the posterior ligamentous complex and neural structures in a direct manner, enhancing the ability to detect occult instability. The results indicated that there was often cortical tissue injury that was not visible on computed tomography (CT) imaging, beyond the obvious disruption.

Results of the present comparative imaging studies showed good agreement with earlier imaging studies. In a similar study, Soufi et al. (2024) confirmed MRI's ability to detect neural and ligamentous injuries in addition to CT. They found MRI changed the fracture classification and treatment plan in a clinically significant number of thoracolumbar trauma patients, and this was similar to the observations in the present study that MRI found instability findings that were not seen on X-rays. (Soufi, 2024) In addition, Azevedo et al. (2024) highlighted the complementary character of diagnostic use of CT and MRI in spine trauma evaluation. (Azevedo, 2024)

The current study, however, showed a greater use of CT as the initial imaging modality for trauma, possibly due to the availability of imaging and emergency workflow. Financial constraints, frequent overcrowding in trauma centres and shortage of scanners may result in MRI use in Pakistani trauma centres being somewhat selective. Part of this disparity might be attributed to these contextual factors when compared to higher resource health care systems.

5.2 Clinical Implications

Study results showed significant implications for pathways for imaging in emergency spinal trauma. Considering the high ability of fracture characterization, the speed of acquisition and availability of CT, it still remains the first-line modality. However, selective MRI integration seems to be necessary in patients with neurological deficit, suspected posterior ligamentous injury, and nondeterminate fracture stability and/or persistent clinical symptoms without adequate CT findings. (Bazira, 2021)

Occult instability identified by MRI could be a significant factor to consider in neurosurgical planning and could deter underestimation of unstable trauma. The results also indicate that limiting the use of MRI to cases of spinal trauma by selectively ordering it based on CT morphology and neurological examination is superior. (Falcão L. e., 2025)

The findings of the present study were of special relevance to the trauma centers in resource limited health care system like Pakistan. In many regional hospitals, financial cost, limited availability of MRI scanners and growing burden of trauma impact the accessibility of MRI. Therefore, the use of CT-first imaging approach remains the most convenient approach in many institutions.

However, the use of selective MRI incorporation seems clinically appropriate in patients with neurological symptoms, posterior element injury suspicion, and/or ambiguously stable fracture. Efficient management of trauma patients with a balance of diagnostic sensitivity and utilization of resources, which could be achieved with rational imaging pathways, may be more beneficial in reducing unnecessary MRI demand. (Enache, 2025)

The strengths of the study are highlighted as:

There were a number of significant strengths in the study. The combination of paired CT–MRI allowed for a direct comparison of imaging findings within the same patient population. Trauma imaging data from the real-world provided useful context to findings and increased the clinical relevance of the results in the context of acute spinal injury practice. The study also provided local evidence of the patterns of spinal trauma imaging in a tertiary care setting in Pakistan, which is poorly represented in the literature to date.

6 . Conclusion

The present study showed that CT and MRI complement each other in the evaluation of VCFs caused by trauma. Due to the excellent osseous resolution and immediate availability in emergencies, CT was an excellent tool for assessing fracture morphology, cortical disruption, involvement of the posterior wall, retropulsion and spinal canal compromise. (Bazira, 2021) MRI, however, was shown to be significantly more sensitive with the ability to visualise the bone marrow edema, injury to the posterior ligamentous complex, spinal cord compression, epidural hematoma, and associated soft-tissue abnormalities.

The results suggested that a high degree of underdiagnosis of clinically relevant ligamentous and neurological injuries in an exclusive patient subset could exist when using CT only. On the other hand, the use of MRI in routine practice of all vertebral compression fractures might not be feasible in emergency and resource-limited settings. Hence, neither modality should be viewed as stand-alone in all trauma situations. In contrast, selective integration of MRI after the CT evaluation seems to be the most clinically effective diagnostic approach.

The role of CT as the first-line imaging modality in acute spinal trauma will remain as it is the most accessible of the imaging modalities, acquires images quickly and is very accurate in characterising fractures. (Alizada, 2025) MRI should be considered selectively in patients with neurological deficit, suspected injury of the posterior ligamentous complex, and/or equivocal fracture stability, unexplained persistent symptoms or indeterminate CT findings.

Larger patient populations, surgical correlation and long-term neurological follow-up in future prospective multicenter studies are recommended for further refinement of the assessment of spinal instability based on imaging. (Bajamal, 2022) New technologies such as artificial intelligence-supported fracture analysis, radiomics, and advanced, MRI-based classification systems could also enhance diagnostic accuracy and standardise trauma imaging procedures in the future for managing spinal trauma.

7. Limitations

Numerous restrictions should be taken into account when interpreting the findings. The retrospect observation type designations did not allow for causal interpretation and relied on previously obtained imaging data. (Azevedo, 2024)The study also was performed in a single-center and a small number of participants, which limits generalizability. Not all patients had surgical correlation and long-term neurological outcomes. In addition, there was no thorough interobserver variability analysis of the radiological interpretations, potentially affecting the consistency of the interpretations.

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