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Should the priority examination in spinal trauma be magnetic resonance imaging or computed tomography?

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ABSTRACT

Aim: To determine how to use magnetic resonance imaging (MRI) and computed tomography (CT), which are diagnostic methods, most efficiently for the rapid and accurate diagnosis of spinal trauma in trauma patients who apply to the emergency department.

Methods: For this purpose, 118 patients who apply to the emergency department and the neurosurgery outpatient clinic due to multiple trauma were scanned, retrospectively. The patient's history, MRI, CT and plain radiographs were evaluated in parallel with the patient's clinical findings. Descriptive statistical analysis of MRI and CT findings were performed and the findings were compared.

Results: In the present study, 33.9% of the patients were women and 66.1% were men. In our study, no fracture was detected in the CT or MRI images of 9% of the patients who suffered trauma. We found that 91% of vertebral fractures were missed in the evaluation based on clinical history and CT results. Later, with the MRI taken, the most fractures in women were detected in the 12th thoracic vertebra. In men, the most trauma was detected in the first lumbar vertebra. MRI examination revealed fractures in all patients. Therefore, detection of vertebral injuries missed by CT with MRI is of great importance in terms of spinal cord injuries. It was found statistically significant that vertebral injury detection was higher in the MRI system than in CT (p<0.05).

Conclusion: It is vital that every patient admitted to the hospital due to spinal trauma be scanned with an MRI-Short tau inversion recovery (STIR) sequence as the initial examination of the entire spine, and once the affected area is identified, the area or areas should be re-evaluated with CT. A screening should be performed and then the treatment method should be defined.

Key words: Spinal cord injuries, vertebral body fracture, diagnostic imaging, magnetic resonance imaging, STIR sequence, tomography.

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1. Introduction

Spinal injuries can lead to consequences that reduce the quality of life, especially in cases where the spinal cord is damaged or may be damaged. It is vital to detect and diagnose conditions that can lead to such serious consequences. Detection of fractures in spinal traumas and medical treatment management of post-traumatic patients depend entirely on diagnosis. Early diagnosis depends primarily on a good neurological examination [1]. In some traumas, spinal fractures may not be visible on direct radiography or computed tomography and may be overlooked. If patients act as if nothing is wrong, medulla spinalis or radix compression may occur depending on the progression of the

fracture. For this reason, MRI (especially the use of STIR sequence) in the examination of trauma patients is very useful in detecting fracture-related edema in the spine that is not very serious at that moment. For this reason, in trauma cases, especially when there are fractures in the posterior elements, it is vital to first obtain an MRI with STIR sequence and especially a thin-section CT scan from the area where edema is detected in the spine and make treatment decisions accordingly [2,3]. The aim of this study is to determine how to use MRI and CT, which are diagnostic methods, most efficiently for the rapid and accurate diagnosis of spinal trauma in trauma patients who apply to the emergency department.

2. Materials and metods

Patients whose spinal injuries can lead to consequences that reduce the quality of life, who apply to the hospital's emergency department and neurosurgery outpatient clinic due to spinal trauma, and whose MRI, CT and plain x-rays were taken, were included in the study. The study was approved by the Ethics Committee of the University of Pamukkale (Date: 25/02/2022, Number: E-60116787-020-175902). MRI (Tesla 7.0), CT and plain radiographs of the patients were scanned from the PACS system or e-pulse system. These findings were examined retrospectively and the fractures were also evaluated. The files of 118 patients, 40 women and 78 men, who apply to the emergency department and neurosurgery outpatient clinics due to multiple trauma were examined. The patient's history, MRI, CT and plain radiographs were evaluated. The priorities of MRI and CT evaluations were compared according to fracture detection. Because rapid detection of the fractures and the spinal cord injuries is vital.

2.1. Statistical analyses: Statistical Package for Social Sciences (SPSS) 25 statistical package program was used to calculate the data. Continuous variables are expressed as mean ± standard deviation, minimum and maximum values, and categorical variables as numbers and percentages. Differences between categorical variables were examined with Chi square analysis and Fisher's Exact test. In all analyses, $p<0.05$ was considered statistically significant.

3. Results

33.9% of the patients were female and 66.1% were male. It was observed that the average age of women was 42 and men was 55 (Graphic 1). The most fractured vertebra in women was at T12 with 20%. The second rate was in L1 with 10%. Fracture at L3 was 7.5%. Fractures at L3 and T11-L1 were 5%. Finally, the fracture rate in all other vertebrae was 2.5%. The most broken vertebra in men was the L1 vertebra with 30.72%. The fractured vertebra at T12 was 10.24%. Fractures at L3, L4 and L5 were 3.84. Fractures L1-L3, T10, T11, T11-L1, T5, T6, and T8 were 2.56%. The fracture rate in all other vertebrae was 1.28%.

In our study, no fracture was detected on CT or MR images of 9% of the traumatized patients. 6 of them were women and 5 were men. In the evaluation made based on clinical history and CT results, we found that 91% of vertebral injuries were missed. Later, with the MRI taken, the most fractures in women were detected in the 12th thoracic vertebra. In men, the most trauma was detected in the first lumbar vertebra (Table 1).

MRI examination revealed that all patients had vertebral fractures. For this reason, the detection of vertebral injuries missed by CT with MRI is of great importance in terms of medulla spinalis injuries (Figure 1). It was found statistically significant that the detection of spinal cord injuries was higher in the MRI system than in CT ($p<0.05$).

Table 1. Number of cases and average age of vertebral fracture in the minimum and maximum range.

Female				Male			
Fracture	Cases	%	Age-mean (min-max)	Fracture	Cases	%	Age-mean (min-max)
C2 fracture	1	2.5	40	C1-2 fracture	1	1.28	24
				C2 fracture	1	1.28	32
				C5 fracture	1	1.28	39
				C6 fracture	1	1.28	35
				C7 fracture	1	1.28	56
C3 fracture	1	2.5	54	C2-C3 fracture	1	1.28	74
L1 fracture	4	10	52 (28-92)	L1 fracture	24	30.72	49 (26-85)
L1-2 fracture	1	2.5	25	L1-L2 fracture	1	1.28	54
L2 fracture	3	7.5	57 (51-62)	L2 fracture	3	3.84	55 (48-60)
L3 fracture	2	5	38 (34-62)	L2-L3 fracture	1	1.28	56
L3-L4 fracture	1	2.5	26	L3 fracture	3	3.84	55 (48-60)
L4 fracture	1	2.5	51 (27-74)	L4 fracture	3	3.84	52 (26-63)
				L5 fracture	1	1.28	40
				L1-L3 fracture	2	2.56	57 (42-72)
				T10-T11 fracture	1	1.28	68
				T10 fracture	2	2.56	64 (61-67)
T11 fracture	1	2.5	47	T11 fracture	2	2.56	56 (35-67)
T11-12 fracture	1	2.5	60	T11-12 fracture	1	1.28	71
T11-L1 fracture	1	2.5	29	T12 fracture	8	10.24	56 (38-93)
T11-L1 fracture	2	5	37	T11-L1 fracture	2	2.56	33 (29-37)
T12 fracture	8	20	56 (38-93)	T2 fracture	1	1.28	56
T12-L1 fracture	1	2.5	46	T5 fracture	2	2.56	59 (36-82)
T3-4 fracture	1	2.5	52	T5-6 fracture	1	1.28	35
T4 fracture	1	2.5	34	T5-T8 fracture	1	1.28	37
T5 fracture	1	2.5	39	T6 fracture	2	2.56	33 (32-34)
T5-6 fracture	1	2.5	24	T7 fracture	1	1.28	45
T5-6-7 fracture	1	2.5	49	T8 fracture	2	2.56	38 (34-41)
T6 fracture	1	2.5	41	T7-8 fracture	1	1.28	30
				T8-9 fracture	1	1.28	51
				T9-10 fracture	1	1.28	43
NORMAL FINDINGS	6	15			5	6,4	
Total	40	100			78	100	

C; Cervical, T; Thoracic, L; Lumbal

Figure 1. There was no evidence of a fracture at T12 in the lumbar CT imaging taken after the trauma. However, in the MR-STIR sequence, it is clearly seen that there is sign of edema in the T12 vertebra.

4. Discussion

Spinal trauma that occur after falls, traffic accidents, and heavy lifting that strain the spine are very common problems in the emergency department. Depending on the area where the fracture occurs, it can cause life-threatening, serious disabling problems such as quadriparesis and paraparesis. Symptoms of complete spinal cord transection depend on the level of injury. High cervical injury results in respiratory failure, quadriplegia, and loss of sphincter tone. Higher thoracic lesions cause paraplegia or quadriparesis. Lower thoracic and lumbosacral injuries present with bowel and urinary retention. The cause of cord amputation may be fracture caused by dislocation of vertebral bodies/bone fragments or direct penetrating trauma from a gun, bullet or other foreign object [3].

Spinal cord injury is a dramatic situation. The psychology of post-traumatic paralyzed patients and their relatives is negatively affected, and it also brings a financial burden to the state. From this perspective, the management of patients with spinal cord trauma begins at the place where the trauma occurs, before entering the emergency room. Early diagnosis positively affects mortality and morbidity [3,4,5].

Fractures in the thoracolumbar region are quite common in spinal traumas, and approximately 90% of the fractures in this region involve the thoracolumbar junction (T10-L2). Up to one-third of thoracolumbar fractures are complicated by spinal cord injury [6,7]. In our study, the most fractures in women were detected in the 12th thoracic vertebrae. In men, the most trauma was detected in the first lumbar vertebrae as in literature.

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Thoracolumbar spine fractures are closely related with spinal cord injury, long-term pain, and decreased quality of life. Among individuals with spinal cord injuries who reach the emergency department, the second most common neurological deficit (after incomplete tetraplegia) is complete paraplegia (27.9%), followed by incomplete paraplegia (21.3%), both of which result from thoracolumbar injuries. Only less than 1% of patients with spinal cord injury fully recover before discharge [8,9].

In young patients with spinal cord injuries and thoracolumbar spine trauma, costs in terms of lifelong lost productivity are added to medical treatment and rehabilitation expenses.

Spinal cord injury is a result of instability of the spine. With the appropriate use of MRI, CT and plain radiographs, spinal instability is revealed and treatment options are directed accordingly. For this reason, treatment classifications and protocols have been created. The common goal of any classification scheme through imaging is to determine the presence and degree of spinal instability to promote optimal treatment and improve outcome. Radiological evaluation of thoracolumbar spine injuries begins with evaluation of the structural integrity and alignment of the vertebra and morphological damage with radiographs and CT [10]. Traditionally, standing or supine anteroposterior and lateral radiographs serve to demonstrate the level and type of fractures. However, if the spinal cord injury is not serious enough to cause serious damage to the spine, it may not be seen with direct x-ray and CT, which are classical diagnostic methods, and may be overlooked unknowingly.

For this reason, every trauma patient who comes to the emergency department to scan the spine or other body parts should have an MRI with STIR sequence, CT should be performed on the spinal areas where STIR secant edema is detected, multiplanar reconstructions should be performed and voluminous images should be obtained, and the dimensions of the fracture should be better revealed. Treatment planning should be made accordingly. Following these steps provides a better assessment of bone

anatomy compared to plain x-rays that are first offered to patients coming to the emergency department. CT also analyzes fractures in much more detail by detecting the condition of the posterior vertebral body, the location or displacement of fragments, and damage to the posterior elements. Similarly, in our study, we found that 91% of spinal injuries were missed in the evaluation made based on clinical history and CT results. We found statistically significant that the detection rate of spinal vertebra injuries was higher using MRI than CT ($p<0.05$). Therefore, detection of vertebral injuries missed by CT with MRI is of great importance in terms of spinal cord injuries.

Additionally, Dual-energy CT is a newer method that can be used in conjunction with MRI to investigate the condition of discs and ligaments as well as the acuity of spinal bone fractures through correct functional and numerical analysis [11].

MRI is the gold standard for demonstrating ligament and disc injuries, and although there are many studies claiming that it cannot replace CT as the primary imaging modality in evaluating bone injury in the acute phase, we found MRI to be more effective in this study. Thanks to the STIR sequence, it is more successful in detecting bone edema in spinal traumas than CT. We have proven that it can display this accurately. We did not find any study on this subject in the literature. From this perspective, we think that our study will lead to such studies.

MRI has long been believed to have a primary role in the evaluation of spinal cord changes and soft tissue examination. Conventional MRI provides important information about potential functional cord complications that develop after trauma, which is significant for outcome prediction.

Advanced MRI methods are emerging with great potential to improve the definitive diagnosis and treatment of spinal trauma. Diffusion Tensor Imaging (DTI) and functional MRI (fMRI) have demonstrated only limited clinical use to date; DTI has the strongest evidence [12]. Despite challenges in terms of cost, availability, accessibility, and specificity, conventional MRI and advanced MRI techniques should increasingly be used in all spinal cord injuries.

MRI is the method of choice in the evaluation of patients with neurological signs or symptoms suggestive of SCI (Spinal Cord Trauma) in the setting of acute trauma. Intramedullary edema appears hyperintense on T2-weighted and Short Tau Inversion Recovery (STIR) MRI sequences. At short-medium TI values (STIR), it highlights tissues with long T1 and T2 intervals (tissues with increased free fluid content, such as spinal cord trauma, tumor, infection), that is, it allows the pathology to be seen more clearly. [2, 3, 13, 14].

A multicenter prospective study was conducted by Akland et al. on the patients who were neurologically intact, alert, and with persistent tenderness. They found a 44% injury rate on MRI following negative CT. [15]. Onue et al. showed that 81 of 259 patients had cervical injury on MRI after negative CT [16]. Atsina et al. compared 145 patients who underwent whole spine CT and MRI; the rate of bone damage missed by CT but detected by MRI was 16.9% [17]. MRI is also the only imaging method that allows direct visualization of ligaments and injuries in the spine. Ligamentous structures at the craniocervical (CC) junction are subject to post-traumatic wear or tear. Important ligaments of the CC junction include the apical, alar, transverse and cruciate ligaments, as well as the tectorial, atlanto-occipital and posterior atlanto-axial membranes. Alar and transverse ligaments may normally have variable structure and signaling properties, limiting their evaluation on post-traumatic MRI. Injury to other ligaments at

the 16 CC junction can be recognized by signal abnormalities reflecting bleeding or edema. 17 Fat-suppressed T2-weighted imaging may be useful in detecting edema due to ligament injury. Since it is not possible to detect ligament injuries in the cervical region with CT and direct x-rays taken in the emergency department, especially in patients with polytrauma where it is not known what kind of trauma they were exposed to, in patients with more head trauma, in these cases who come to the emergency department primarily in pediatric traumas due to the head being larger than the body. MRI and especially Stir sequence need to be examined. It is very important to understand the importance of having an MRI-STIR. [3, 18, 19].

When the literature was examined, no other study was found that was similar to our study and emphasized that MRI with STIR sequence can be used as the initial examination in spinal traumas. As can be seen from the above information, Magnetic resonance imaging (MRI) method plays an important role in the evaluation of patients with spinal disorders. Additionally, it provides excellent evaluation of both normal and pathological anatomy [20, 21, 22].

MRI findings may not always be easy to interpret. . Because anatomical abnormalities may not correlate with clinical symptoms. Additionally, the MRI method may show abnormal findings in asymptomatic individuals. Using a systematic approach to interpreting spinal MRI can help to reach the correct diagnosis. MRI can also guide therapeutic decision-making, surgical intervention, and treatment monitoring [23, 24, 25]

4.1. Conclusions

Spinal trauma is a clearly common form of injury. Early detection of spinal trauma is vital. For this reason, MRI (STIR) is very important in spinal traumas in the early diagnosis of trauma-related edema and the location of the fracture. Once the location of the trauma is determined, a tomography can be performed and a clearer decision on the treatment method can be made. Using a systematic approach to interpreting spinal MRI can help reach an accurate diagnosis and guide therapeutic decision making, surgical intervention, and treatment monitoring.

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References

[1]Sheerin F, Collison K, Quaghebeur G. Magnetic resonance imaging of acute intramedullary myelopathy: radiological differential diagnosis for the on-call radiologist. Clin Radiol. 2009; 64(1): 84-94.

[2]Koşar P. Manyetik Rezonans Görüntülemede Temel Sekanslar. Türk Radyoloji Seminerleri. 2020; 8: 69-184.

[3] Gold M. Magnetic Resonance Imaging of Spinal Emergencies. Top Magn Reson Imaging. 2015;24(6):325-30.

[4] Kawakyu-O'Connor D, Bordia R, Nicola R. Magnetic Resonance Imaging of Spinal Emergencies. Magn Reson Imaging Clin N Am. 2016;24(2):325-44.,

[5] Babu, Jacob M., et al. Spinal emergencies in primary care practice. Am J Med. 2019; 132(3): 300-306.

[6] Parizel PM, van der Zijden T, Gaudino S, et al. Trauma of the spine and spinal cord: imaging strategies. Eur Spine J. 2010;19 Suppl 1(Suppl 1):S8-17.

[7] zzo R, Al Qassab S, Popolizio T, et al. Imaging of thoracolumbar spine traumas. Eur J Radiol. 2022;154:110343.

[8] Koksal I, Alagoz F, Celik H, et al. Timing of Surgery for Spinal Fractures Associated with Systemic Trauma: A Need for a Strategic and Systemic Approach. Turk Neurosurg. 2016;26(3):411-5.

[9] Mabray MC, Talbott JF, Whetstone WD, et al. Multidimensional Analysis of Magnetic Resonance Imaging Predicts Early Impairment in Thoracic and Thoracolumbar Spinal Cord Injury. J Neurotrauma. 2016;33(10):954-62.

[10] Takhtani D, Melhem ER. MR imaging in cervical spine trauma. Clin Sports Med. 2002;21(1):49-75.

[11] O'Connor E, Walsham J. Review article: indications for thoracolumbar imaging in blunt trauma patients: a review of current literature. Emerg Med Australas. 2009;21(2):94-101.

[12] Nemsadze G, Lapiashvili E, Urushadze O, et al. Role of multislice spiral computed tomography in diagnosis of spinal injuries in polytrauma patients. Georgian Med News. 2011;11(200):42-51.

[13] Dennis R. Optimal magnetic resonance imaging of the spine. Vet Radiol Ultrasound. 2011;52(1.1): 72-80.

[14] Nudelman B, Mittal A, Rosinski A, et al. Whole-Spine Magnetic Resonance Imaging: A Review of Suggested Indications. JBJS Rev. 2021;14;9(7).

[15] Ackland HM, Cameron PA, Varma DK et al. Cervical spine magnetic resonance imaging in alert, neurologically intact trauma patients with persistent midline tenderness and negative computed tomography results. Ann Emerg Med. 2011; 58(6): 521–30.

[16] Onoue K, Farris C, Burley H, et al. Role of cervical spine MRI in the setting of negative cervical spine CT in blunt trauma: Critical additional information in the setting of clinical findings suggestive of occult injury. J Neuroradiol. 2021;48(3):164-169.

[17] Atsina KB, Rozenberg A, Selvarajan SK. The utility of whole spine survey MRI in blunt trauma patients sustaining single level or contiguous spinal fractures. Emerg Radiol. 2019;26(5): 493-500.

[18] Lall, Neil U, Nicholas V. Stence, and David M. Mirsky. Magnetic resonance imaging of pediatric neurologic emergencies. Topics in Magnetic Resonance Imaging. 2015; 24(6): 291-307.

[19] Khanna AJ, Wasserman BA, Sponseller PD. Magnetic resonance imaging of the pediatric spine. J Am Acad Orthop Surg. 2003;11(4):248-55.

[20] Machino M, Yukawa Y, Ito K, et al. Can magnetic resonance imaging reflect the prognosis in patients of cervical spinal cord injury without radiographic abnormality? Spine (Phila Pa 1976). 2011;36(24):E1568-72.

[21] Foster G, Russell B, Hibble B, et al. Magnetic resonance imaging cervical spine in trauma: A retrospective single-centre audit of patient

outcomes. Emerg Med Australas. 2022;34(1):65-72.

[22] Mathieu J, Talbott JF. Magnetic Resonance Imaging for Spine Emergencies. Magn Reson Imaging Clin N Am. 2022;30(3):383-407.

[23] Shepard, Nicholas, et al. A Practical Approach to Spine Magnetic Resonance Imaging. JBJS reviews 2020; 8 (3): e0099.

[24] Mahajan P, Jaffe DM, Olsen CS, et al. Spinal cord injury without radiologic abnormality in children imaged with magnetic resonance imaging. J Trauma Acute Care Surg. 2013;75(5):843-7.

[25] Demaerel, Philippe. Magnetic resonance imaging of spinal cord trauma: a pictorial essay. Neuroradiol. 2006; 48 (4): 223-232.