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Differentiating Benign and Malignant Causes of Collapsed Vertebrae through MRI Imaging: A Comprehensive Study

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Abstract
Background: Collapsed vertebrae affect many individuals worldwide. The high contrast and soft tissue resolution and multiplanar capabilities of MRI Imaging make it the modality of choice for evaluating soft tissue lesions, early in the disease process. Present study is aimed to evaluate cases of collapsed vertebrae by MRI in differentiating the causes by benign and malignant nature.
Material & Method: This observational study was conducted in the department of Radio Diagnosis, Krishna Institute of Medical Sciences and Hospital. All the patients referred to department of Radio diagnosis with clinical symptoms and signs of low back pain were subjects. Patient's data were analysed using SPSS v21 operating on windows 10.
Results: In present study, total of 64 patients fulfilling inclusion criteria are included after taking informed consent. The mean age of patients was documented as 43.14±17.48yrs. In present study, there was significant enhancement seen on contrast MRI study T1WC in patients with patients with malignancy (66.7%). MRI Findings STIR showed hyperintense findings in all patients with malignancy.
Conclusion: significant association and findings of the MRI in differentiating the compression features and etiological features to find the malignant from non-malignant features, trauma and infective causes.
Keyword: Malignancy, Trauma, MRI, Infective, Vertebrae

Introduction

Collapsed vertebrae, commonly known as vertebral compression fractures (VCFs), represent a significant clinical challenge affecting a considerable portion of the global population, particularly among the elderly and individuals with predisposing risk factors such as osteoporosis, malignancy, and trauma [1,2]. These fractures not only contribute to debilitating

pain and functional impairment but also pose substantial economic burden due to increased healthcare utilization and prolonged hospitalization [3].

The underlying etiology of collapsed vertebrae is diverse, encompassing a broad spectrum of conditions ranging from benign osteoporotic fractures to malignant tumors and infectious diseases [4]. Accurate and timely diagnosis of the underlying cause is paramount for implementing appropriate management strategies tailored to the specific etiology, thereby optimizing clinical outcomes and minimizing complications [5].

In recent years, magnetic resonance imaging (MRI) has emerged as a pivotal diagnostic tool in the evaluation of spinal pathologies, owing to its superior soft tissue contrast resolution, multiplanar imaging capabilities, and absence of ionizing radiation [6]. Unlike conventional radiographic techniques, which primarily provide morphological information, MRI offers detailed visualization of soft tissue structures, enabling early detection of subtle abnormalities and differentiation between benign and malignant lesions [7].

Despite the growing utilization of MRI in spinal imaging, there remains a significant gap in the literature regarding its role in differentiating the causes of collapsed vertebrae. Most studies to date have predominantly focused on the morphological characteristics of vertebral fractures, without adequately addressing the underlying etiology [8]. Moreover, the existing literature lacks consensus on the specific MRI findings indicative of benign versus malignant causes of collapsed vertebrae, leading to diagnostic challenges and potential delays in appropriate management [9].

Given the clinical significance and potential implications for patient management, there is an urgent need for comprehensive studies evaluating the utility of MRI in differentiating between benign and malignant causes of collapsed vertebrae. The present study aims to address this gap by systematically analyzing MRI findings in patients with collapsed vertebrae, with a specific focus on distinguishing between benign and malignant etiologies. By elucidating the distinctive MRI features associated with each etiological category, this study aims to facilitate more accurate diagnosis, timely intervention, and improved clinical outcomes for patients with collapsed vertebrae.

Material and methods

The study aimed to explore the role of MRI in differentiating between benign and malignant causes of collapsed vertebrae in patients presenting with low back pain. Conducted over a three-year period from 2019 to 2022, the study included 64 patients who met the selection criteria, encompassing both male and female individuals across various age groups.

Inclusion criteria comprised patients experiencing low back pain with positive findings on X-ray and those requiring preoperative assessment. Exclusion criteria encompassed patients with contraindications to MRI, including the presence of pacemakers, metallic implants, cochlear implants, bone and joint prostheses, and claustrophobia, as well as pregnant women.

Data collection involved documenting patients' demographic details, including age, sex, occupation, habits, height, weight, medication history (corticosteroid/opioids), and hospital identification numbers. Clinical symptoms and signs were recorded alongside the clinical diagnosis from the case. Informed written consent was obtained from all participants in both English and local languages, and body mass index (BMI) was calculated based on patients' height and weight.

MRI scans were performed on all patients using a 1.5 Tesla SIEMENS MAGNETOM AVANTO (TIM + DOT) MRI machine. The imaging protocol included T1-weighted sagittal images, T2-weighted axial, coronal, and sagittal images, Short Time Inversion Recovery (STIR) sequences, and post-contrast MRI with gadolinium IV injection as required. Prior to the MRI scan, patients were provided with disposable earplugs to minimize noise discomfort, and all metallic objects were removed to avoid image distortion.

Statistical analysis was conducted using SPSS v21 software on Windows 10, with demographic details summarized as frequency, percentage, mean, and standard deviation. The mean difference between continuous data was analyzed using unpaired t-tests, while categorical data were assessed using chi-square tests. Diagnostic accuracy was evaluated using the area under the receiver operating characteristic (ROC) curve, with sensitivity, specificity, accuracy, positive predictive value, and negative predictive value calculated to measure the study's diagnostic performance. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Demographic Characteristics and Lesion Site Distribution

In the present study, a total of 64 patients with collapsed vertebrae were evaluated using MRI to differentiate between benign and malignant causes. The mean age of the patients was 43.14 years, with a relatively equal distribution between male (46.9%) and female (53.1%) patients. Regarding the distribution of lesion sites, the majority of the lesions were located in the dorsal region (53.1%), followed by the lumbar region (39.1%) and the cervical region (7.8%). These demographic and lesion site distributions provide a foundational understanding of the study population, highlighting the need for a comprehensive MRI evaluation to differentiate between various etiologies of collapsed vertebrae across different age groups and genders.

Table 2: MRI Findings and Alignment Characteristics

The MRI findings and alignment characteristics revealed significant observations related to the vertebral bodies (VBs) and their alignment. Notably, 96.9% of the patients exhibited bone marrow changes in the VBs, indicating potential pathological alterations. In terms of VBs alignment, an equal distribution was observed between normal alignment and lost alignment, with 50.0% of patients in each category. These MRI findings underscore the importance of evaluating both structural and alignment changes in the VBs to differentiate between benign and malignant causes of collapsed vertebrae. Additionally, the high prevalence of bone marrow changes highlights the need for further diagnostic investigations to accurately determine the underlying etiology of the vertebral collapse.

Table 3: Contrast MRI and Spinal Cord Characteristics

The study's MRI findings further elucidated the characteristics of the collapsed vertebrae and associated spinal cord changes. In the contrast MRI T1WC evaluation, enhancement was observed in 40.6% of the cases, indicating potential areas of increased vascularity or pathological changes within the vertebrae. Additionally, the MRI Findings STIR revealed hyperintense signals in 71.9% of the cases, suggesting inflammatory or edematous changes within the spinal tissues. These MRI characteristics provide valuable insights into the pathological changes associated with vertebral collapse and emphasize the importance of contrast-enhanced and STIR sequences in delineating the underlying etiology.

Table 4: Neurological Involvement and Diagnosis Remarks

The study also assessed the neurological involvement and provided diagnostic remarks based on the MRI findings. Cord edema was identified in 59.4% of the cases, indicating potential compression or inflammatory changes affecting the spinal cord. Furthermore, cord compression was present in 67.2% of the cases, highlighting the severity and potential implications for neurological function. In terms of diagnostic remarks, a significant majority of the cases were categorized as benign (85.9%), while a smaller proportion were identified as malignant (14.1%). These findings underscore the clinical significance of evaluating neurological involvement and providing accurate diagnostic remarks based on comprehensive MRI evaluations to guide treatment planning and surgical interventions effectively.

Discussion

The current study emphasized the indispensable role of magnetic resonance imaging (MRI) in discerning between benign and malignant causes of vertebral collapse, shedding light on the diagnostic and prognostic implications of various imaging findings. The study cohort predominantly comprised females (53.1%) with an average age of 43.14 years, underlining the significance of early and precise diagnostic methods in managing the escalating incidence of vertebral collapse across diverse demographics [1,2].

MRI revealed substantial bone marrow alterations in 96.9% of cases, underscoring the necessity of scrutinizing these changes to distinguish between benign osteoporotic fractures and malignant lesions [7,8]. The distribution of vertebral body alignments was evenly split between normal and lost alignments, underscoring the importance of meticulous structural assessments to determine the severity and potential trajectory of vertebral collapse [7,8].

Contrast-enhanced MRI T1WC highlighted enhancement in 40.6% of cases, indicative of potential neovascularization or pathological modifications within the vertebrae [9]. STIR sequences manifested hyperintense signals in 71.9% of cases, signifying inflammatory or edematous alterations, which could further influence the clinical course and prognosis of vertebral collapse [10,11]. These MRI characteristics play a pivotal role in guiding treatment modalities, surgical interventions, and prognostic evaluations, thereby enhancing patient care and management strategies [9-11].

Neurological involvement was discernible in a substantial proportion of cases, with 59.4% exhibiting cord edema and 67.2% displaying cord compression. These observations accentuate the imperative nature of early detection and intervention to attenuate potential neurological ramifications and ensure favorable outcomes [12-14].

Based on MRI assessments, the majority of cases were categorized as benign (85.9%), while a smaller subset was designated as malignant (14.1%) [13-15]. Such diagnostic insights are pivotal in refining therapeutic approaches, facilitating informed decision-making, and devising personalized care plans tailored to address the distinct clinical presentations and underlying etiologies of vertebral collapse [13-15].

The study findings highlight the diagnostic precision of MRI in the comprehensive evaluation of vertebral collapse, facilitating a nuanced understanding of the diverse pathological changes associated with this condition [1-15]. Despite the clinical challenges posed by the overlapping features of benign and malignant pathologies, the unique MRI patterns identified in this study provide valuable diagnostic cues, aiding clinicians in formulating accurate differential diagnoses and enabling targeted interventions [1-15].

Conclusion

In conclusion, the study demonstrates the pivotal role of MRI in differentiating between benign and malignant causes of collapsed vertebrae, offering valuable diagnostic insights that guide treatment planning and optimize patient care. The high prevalence of bone marrow changes, hyperintense signals, and neurological involvement observed underscores the complexity and clinical significance of vertebral collapse. These findings emphasize the importance of early detection, accurate diagnosis, and timely intervention to mitigate potential complications, ensure favorable outcomes, and tailor personalized management strategies. The study highlights the necessity for comprehensive MRI evaluations in assessing vertebral pathologies, refining treatment approaches, and enhancing prognostic assessments to address the diverse clinical presentations and underlying etiologies associated with collapsed vertebrae effectively. Future research should focus on exploring advanced imaging techniques and integrating multi-parametric analyses to further enhance diagnostic accuracy, prognostic predictions, and therapeutic outcomes in patients with vertebral collapse.

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Tables

Table 1: Demographic Characteristics and Lesion Site Distribution

Parameter	Total (N=64)	Percent (%)
Mean Age (years)	43.14	-
Gender		
- Female	34	53.1
- Male	30	46.9
Lesion Site		
- Cervical	5	7.8
- Dorsal	34	53.1
- Lumbar	25	39.1

Table 2: MRI Findings and Alignment Characteristics

Parameter	Total (N=64)	Percent (%)
VBs Bone Marrow Changes		
- Absent	2	3.1
- Present	62	96.9
Alignment of VBs		
- Lost	32	50.0
- Normal	32	50.0

Table 3: Contrast MRI and Spinal Cord Characteristics

Parameter	Total (N=64)	Percent (%)
Contrast MRI T1WC		
- Enhancement Not Seen	24	37.5
- Enhancement Seen	26	40.6
MRI Findings STIR		
- Hyperintense	46	71.9
- Normal	18	28.1

Table 4: Neurological Involvement and Diagnosis Remarks

Parameter	Total (N=64)	Percent (%)
Cord Edema		
- Absent	26	40.6

- Present	38	59.4
Cord Compression		
- Absent	21	32.8
- Present	43	67.2
Remarks		
- Benign	55	85.9
- Malignant	9	14.1