e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15 (12); 1462-1468

Original Research Article

A Study on Role of Magnetic Resonance Imaging in Determining the Etiology of Vertebral Collapse

Rahul Singla[1], Shweta Kothari[2*]

[1]Assistant Professor, Department of Radiodiagnosis, Jagannath Gupta Institute of Medical Sciences and Hospital, Kolkata, West Bengal, India

[2]Associate Professor, Department of Radiodiagnosis, Jagannath Gupta Institute of Medical Sciences and Hospital, Kolkata, West Bengal, India

Received: 25-09-2023 / Revised: 28-10-2023 / Accepted: 30-11-2023

Corresponding author: Dr. Shweta Kothari

Conflict of interest: Nil

Abstract:

Background: Osteoporotic vertebral fractures, one of the common causes of vertebral collapse, are a global health concern, particularly affecting the elderly population.

Objective: This study explores the utility of Magnetic Resonance Imaging (MRI) in diagnosing and categorizing vertebral collapse etiologies. Demographic parameters, MRI features, and statistical analysis were considered.

Methods: Involving 52 patients, primarily male, MRI was employed for vertebral collapse diagnosis. Osteoporotic fractures dominated (44%) in the 41-60 age group. Statistical analysis determined the specificity, sensitivity, and accuracy of significant MRI features for malignancy, osteoporosis, and infection.

Results: Osteoporotic fractures prevailed, with specific MRI features showing significance. Malignant fractures exhibited distinctive characteristics, as did infective fractures. Some features demonstrated 100% specificity. Statistical significance was attained for all MRI features.

Conclusion: MRI emerges as a crucial tool for differentiating vertebral collapse etiologies. Osteoporotic fractures predominate, and specific MRI features contribute to precise categorization. Despite limitations, MRI proves reliable for early diagnosis and tailored management, playing a definitive role in determining vertebral collapse aetiology.

Keywords: Vertebral Collapse, Epidemiology, Prevalence, Magnetic Resonance Imaging, Clinical Significance.

Introduction

Vertebral collapse is a multifaceted clinical entity with a spectrum of etiologies, encompassing degenerative, infectious, neoplastic, and traumatic causes. This condition poses a significant healthcare challenge due to its association with considerable morbidity, impaired quality of life, and economic burden.[1,2] The vertebral column, a critical structural component of the axial skeleton, is susceptible to various pathological processes that may lead to collapse.[3,4] Osteoporotic vertebral fractures, one of the common causes of vertebral collapse, are a global health concern, particularly affecting the elderly population.[5] According to the International Osteoporosis Foundation, it is estimated that worldwide, 1 in 3 women and 1 in 5 men over the age of 50 will experience osteoporotic fractures, with vertebral fractures accounting for a substantial proportion[6]. The prevalence of vertebral collapse is closely tied to demographic factors, with an increasing incidence observed in aging populations. Apart from osteoporosis, spinal infections contribute significantly to vertebral collapse.[4,6,7] Tuberculosis, a major infectious cause, remains a critical public health issue, particularly in developing countries. The Global Tuberculosis Report by the World Health Organization reported approximately 10 million new cases of tuberculosis globally in the year 2020, with the spine being a common site of extrapulmonary involvement. [4,8] Neoplastic conditions, including primary bone tumors and metastatic lesions, further underscore the complexity of vertebral collapse. Cancer statistics reveal a rising incidence of various malignancies, emphasizing the need for effective diagnostic strategies to identify spinal involvement.[4,9] According to the American Cancer Society, it was estimated that there would be approximately 1.9 million new cancer cases diagnosed in the United States in 2021[6,10]. Vertebral collapse has profound clinical implications, impacting patients' physical well-being, functional capacity, and overall health-related quality of life. Chronic pain, spinal deformities, and neurological deficits are

common manifestations, leading to disability and dependency. The economic burden associated with vertebral collapse is substantial, encompassing healthcare costs, lost productivity, and the expenses related to long-term care and rehabilitation.[11,12] A study published in the Journal of Bone and Mineral Research highlighted the significant impact of osteoporotic fractures on healthcare costs, reporting that the cumulative 5-year cost of care for a hip or spine fracture patient exceeded $81,000 in the United States[13]. These statistics underscore the urgent need for accurate diagnostic tools that can facilitate early intervention and mitigate the clinical and economic consequences of vertebral collapse.[3,13]

In the context of vertebral collapse, Magnetic Resonance Imaging (MRI) has emerged as a cornerstone diagnostic modality, offering unparalleled advantages in the visualization of soft tissues and detailed anatomical structures.[14,15] The exquisite sensitivity of MRI to pathological changes in the bone marrow, intervertebral discs, and surrounding soft tissues positions it as an indispensable tool for identifying the diverse aetiologies of vertebral collapse. MRI provides a comprehensive assessment of the spine, enabling the detection of subtle changes indicative of osteoporotic fractures. [5,16]

The modality excels in characterizing the extent of bone marrow edema, distinguishing acute fractures from chronic ones, and facilitating timely intervention to prevent further complications. For spinal infections, MRI plays a pivotal role in identifying the site and extent of involvement, aiding in early diagnosis and guiding appropriate therapeutic strategies[17,18]. Amid the complexity of vertebral collapse and its diverse aetiologies, Magnetic Resonance Imaging (MRI) has emerged as a pivotal diagnostic tool. MRI's ability to provide detailed visualization of soft tissues, including the spinal cord, intervertebral discs, and surrounding structures, positions it as a cornerstone in identifying the underlying causes of vertebral collapse. The significance of this study lies in elucidating the specific contributions of MRI in diagnosing and characterizing vertebral collapse, thereby influencing clinical decision-making, treatment planning, and overall patient outcomes.

Methodology

The study was conducted at Jagannath Gupta Institute of Medical Sciences and Hospital (JIMSH), a tertiary level teaching hospital, within the Department of Radiodiagnosis, over duration of one and a half years, spanning from January 1, 2021, to June 2022. This descriptive observational study received clearance from the Institutional Ethical Committee, and informed consent was obtained from all participating patients. The study focused on patients undergoing MRI spine at JIMSH, Kolkata, diagnosed with vertebral collapse based on spine skiagrams. A total of 52 patients were enrolled using random sampling as the sample design.

Study Design and Parameters: The study employed a descriptive observational design to achieve its specific objectives. For Objective 1, identifying various predictors based on MR Imaging to establish the etiology of vertebral collapse, patients were categorized into three broad aetiologies: Malignant, Osteoporotic, and Infectious. Trauma cases were excluded after thorough history-taking. Objective 2 involved grouping the various aetiologies into benign and malignant with the help of various predictors. Objective 3 aimed at evaluating results using tools like sensitivity, specificity, accuracy, bar diagrams, and pie charts.

Study Tools and Techniques: The study utilized a Patient Performa for comprehensive data collection. Imaging was performed using a 1.5-Tesla Scanner (SIEMENS), incorporating various MRI sequences such as T1-weighted and T2-weighted images in axial, sagittal, and coronal planes, T2 STIR sagittal sections, and T1 Fat Saturated with contrast in axial, coronal, and sagittal sections. A specialized Spinal Coil was employed to enhance imaging quality.

Study Techniques: Screening involved patients attending JIMSH for MRI scans of the spine, with informed consents obtained from patients or guardians for minors. Inclusion criteria encompassed patients attending JIMSH for MRI scans of the spine with skiagrams showing any vertebral collapse. Exclusion criteria considered patients with a history of allergic reactions to contrast or other drugs, those with a history of major trauma, individuals with implanted cardiac pacemakers or contraindicated devices for MRI, and patients reporting claustrophobia

This comprehensive methodology integrates a systematic approach, advanced imaging techniques, and meticulous criteria to evaluate the role of Magnetic Resonance Imaging in differentiating the etiology of vertebral collapse, providing a robust framework for the study.

Statistical analysis: Statistical analysis done by using Graph Pad Prism 5 calculated sensitivity, specificity, accuracy, and p-values for individual MRI features. The Chi-squared test indicated statistical significance with a p-value of <0.05.

Result

Demographic distribution of patients: This study's demographic analysis reveals a male preponderance, constituting 59.61% of the 52 patients, with females accounting for 40.38%. The

age distribution illustrates a peak incidence in the 41-60 age group, representing half of the cases, while patients aged 21-40 and >60 contribute 23.07% and 21.15%, respectively.

Osteoporotic fractures emerge as the predominant etiology at 44%, followed by infective at 36% and malignant at 20%, Table 1 and Figure 1.

Table 1: Demographic data of the study

Sex	**Number of Patients**	**Percentage (%)**
Male	31	59.61%
Female	21	40.38%
Total	52	100%
Age Groups	**Number of Patients**	**Percentage (%)**
≤ 20	3	5.76%
21-40	12	23.07%
41-60	26	50.00%
>60	11	21.15%
Total	52	100%
Etiology	**Number of Patients**	**Percentage (%)**
Osteoporotic	22	44%
Malignant	10	20%
Infective	18	36%
Total	50	100%

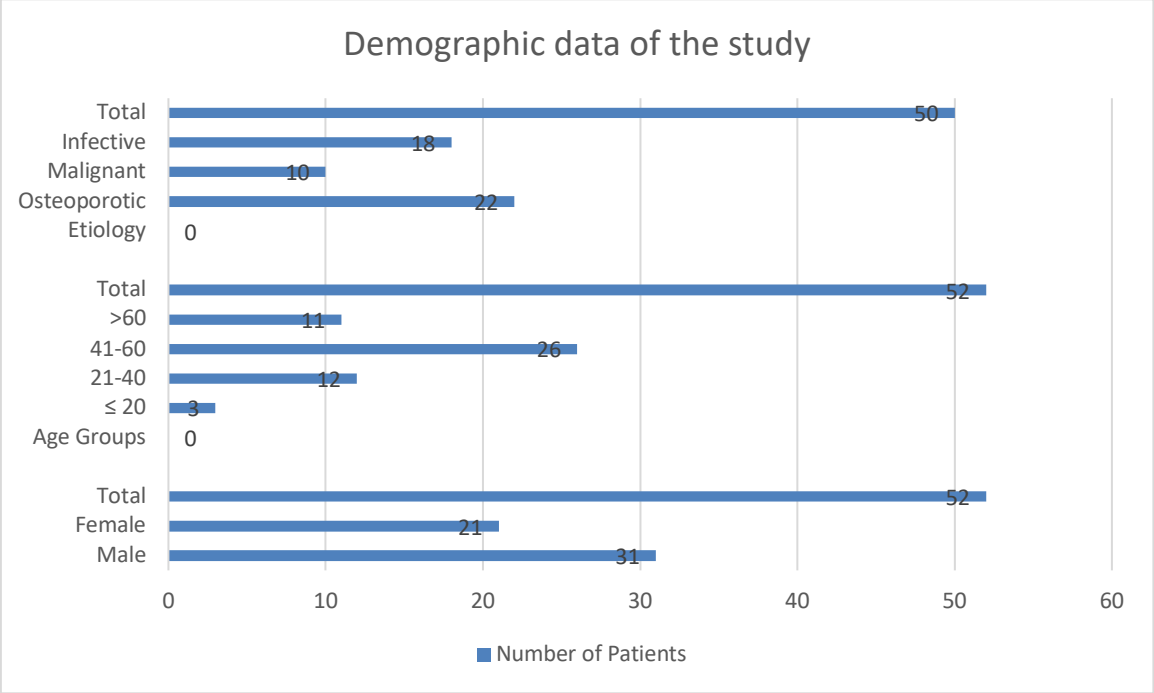

Figure 1: Demographic data of the study

Distribution of patients according to MRI features in Malignant Collapse: The MRI features analyzed in this study provide valuable insights into the differentiation of vertebral collapse etiologies. Among the malignant fractures, the presence of a convex posterior border was identified in 70% of cases, highlighting its significance as a prominent feature in diagnosing malignancy. Posterior elements involvement, observed in 90% of patients, further underscores the importance of evaluating neural element engagement for accurate diagnostic conclusions.

Notably, features like epidural mass, paraspinal mass, and other spinal metastasis displayed percentages of 60%, 70%, and 80%, respectively, Figure 2.

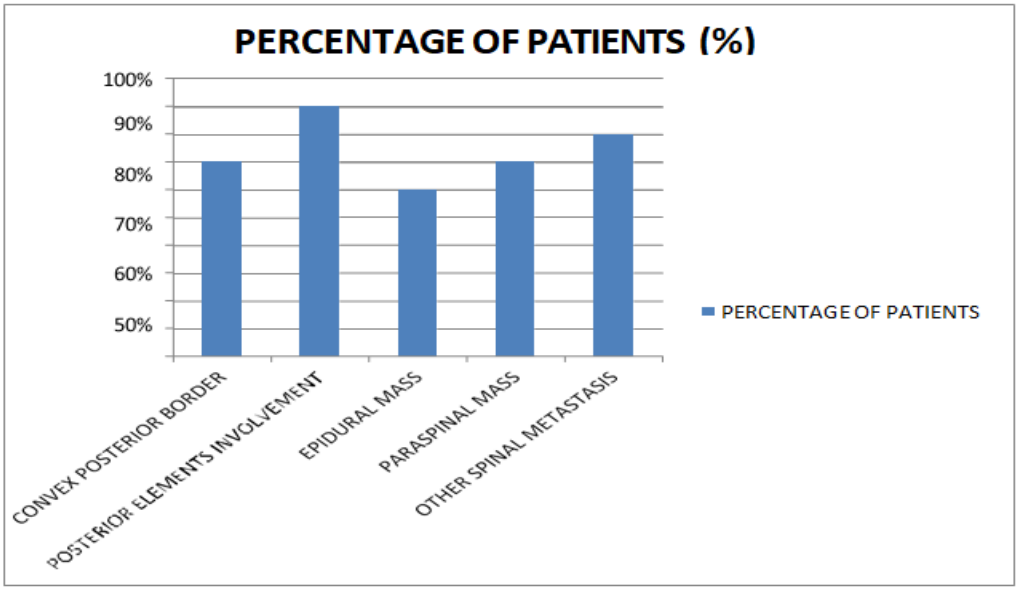

Figure 2: Distribution of patients according to MRI features in Malignant Collapse

Distribution of patients according to MRI features in osteoporotic collapse: In the context of osteoporotic vertebral collapse, the MRI features examined in this study shed light on distinctive characteristics.

Notably, retropulsion was observed in 54% of patients, highlighting its relevance as a prevalent feature in osteoporotic cases. The presence of a low signal intensity band was even more significant, being identified in 82% of patients. This finding underscores the importance of recognizing this feature in MRI assessments for its high association with osteoporotic vertebral collapse. Additionally, the spared normal marrow signal, observed in 77% of cases, further contributes to the comprehensive understanding of MRI manifestations in osteoporotic fractures, Figure 3.

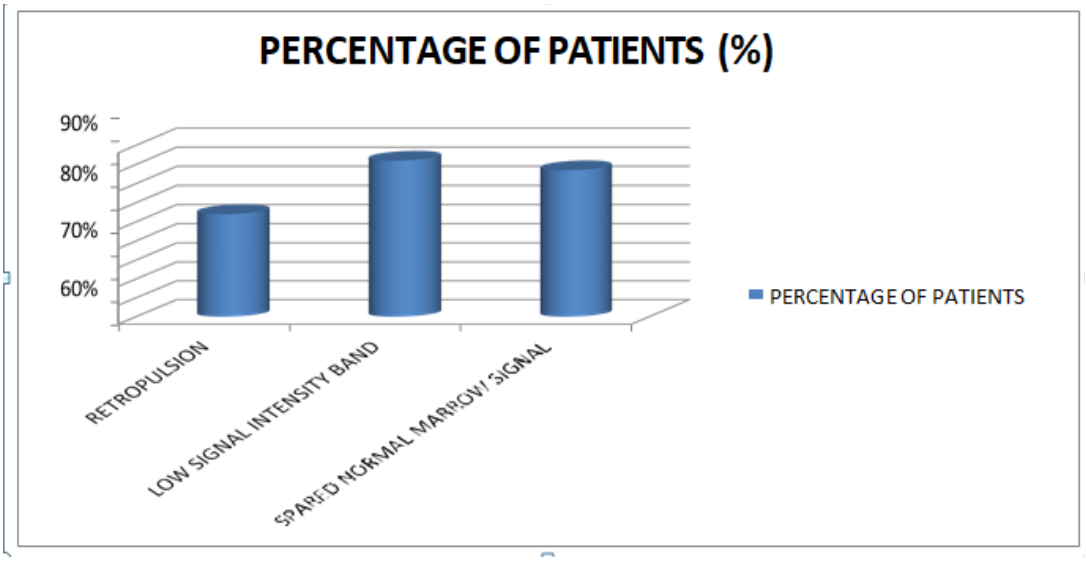

Figure 3: Distribution of patients according to MRI features in osteoporotic collapse

Distribution of patients according to MRI features in infective collapse.

In the evaluation of vertebral collapse with infective etiology, the MRI features assessed in this study highlight key characteristics.

A substantial 88% of patients exhibited contiguous vertebral involvement, underscoring its prevalence in infective vertebral collapse. End plate disruption, identified in 83.3% of cases, serves as a significant radiological marker of infection, complemented by the high occurrence of disc involvement at 94.4%. Paraspinal abscesses were present in 83.3% of cases, further indicating the extension of infection beyond the vertebral bodies. Additionally, epidural abscesses were observed in 72.2% of patients, contributing to the comprehensive understanding of infectious vertebral collapse, Figure 4 and Table 2.

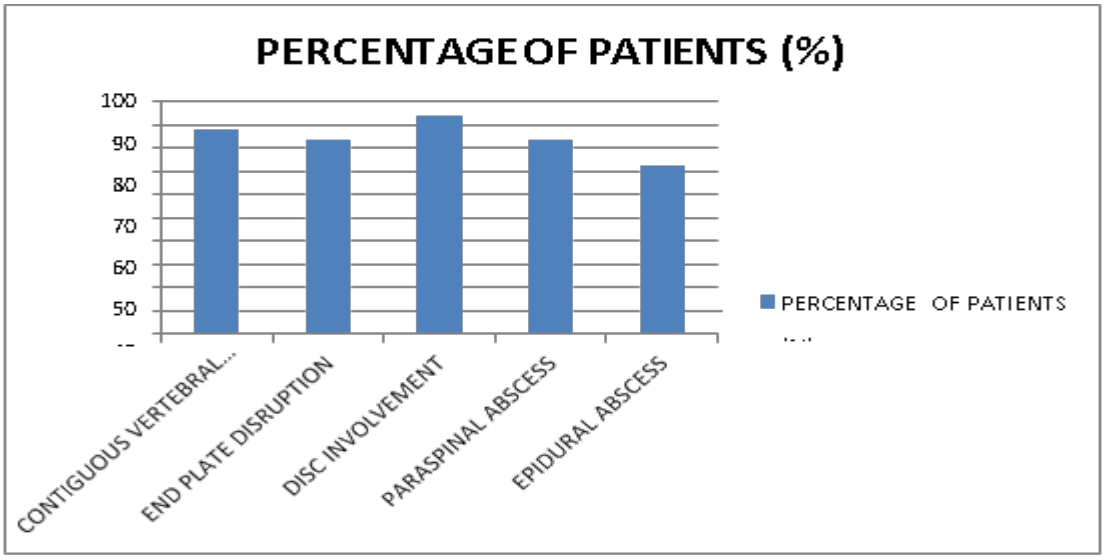

Figure 4: Distribution of patients according to MRI features in infective collapse

Table 2: Magnetic resonance imaging (MRI) features suggestive of malignant, osteoporotic, and infective vertebral compression fractures.

MRI feature	Malignant	Osteoporotic	Infective	Sensitivity	Specificity	Accuracy	P -value
Malignant fracture							
Convex posterior border	7(70)	1(4.5)	0	70	98	92	<0.001
Posterior elements involvement	9(90)	3(13.6)	8(44.4)	90	73	76	<0.001
Epidural mass	6(60)	0	0	60	100	92	<0.001
Paranasal sinus	7(70)	2(9)	2(11.1)	70	90	86	<0.001
Other paranasal sinus	8(80)	0	0	80	100	96	<0.001
Osteoporotic fracture							
Retropulsion		12(54)	1(5.5)	55	96	78	<0.001
Low signal intensity band	1(10)	18(81.8)	1(5.5)	82	93	88	<0.001
Spared normal marrow signal	1(10)	17(77.3)	3(16.7)	77	86	82	<0.001
Infective fracture							
Contagious vertebral involvement	3(30)	7(31.8)	16(88)	89	69	76	<0.001
End plate disruption	2(20)	0	15(83.3)				<0.001
Disc involvement	1(10)	0	17(94.4)	94	97	96	<0.001
Paranasal abscess	0	0	15(18.3)	83	100	94	<0.001
Epidural abscess	0	0	13(72.2)	72	100	90	<0.001

Discussion

The present study sought to employ MRI scans for the radiological diagnosis of vertebral collapse, assess MRI features, and categorize patients based on etiology. In this investigation involving 52 patients, a male predominance was observed, with 59.61% males and 40.38% females, yielding a male-to-female ratio of 1.47:1. The study covered a broad age range, from 13 to 75 years, with the highest incidence of vertebral compression fractures occurring in the 41-60 age groups (50%). The mean age was 49, aligning with the findings of Abdel-Wanis, M. E., et al., [18] who reported a mean age of 59 years in a similar study.

Regarding etiology, osteoporotic fractures were the most prevalent, followed by infective fractures, with malignant fractures being the least common. The evaluation of MRI features, guided by a thorough literature review, revealed distinct characteristics for each etiology. [19,20]. Malignant fractures exhibited features such as a convex posterior border, posterior neural element

involvement, epidural and paraspinal masses, and other spinal metastases. Osteoporotic fractures displayed features like retropulsion, a low signal intensity band, and spared normal marrow signal intensity. Infective fractures manifested characteristics including contiguous vertebral involvement, end plate disruption, disc involvement, paraspinal abscesses, and epidural abscesses.

The differentiation of these etiologies relied on the combination of multiple MRI features, facilitating a comprehensive understanding of the underlying pathology. The study aimed to contribute to the early differentiation between benign and malignant vertebral fractures, crucial for tailored management. Categorizing benign cases into infective and osteoporotic subtypes, 50 patients were classified: 10 as malignant, 22 as osteoporotic, and 18 as infective, with one case requiring biopsy confirmation. Despite its contributions, the study faces limitations, including a relatively small sample size necessitating validation in larger cohorts. Additionally, some cases lacked histopathological confirmation, relying on clinical and radiological follow-up for final diagnosis. This study sheds light on the diagnostic potential of MRI in vertebral collapse etiology, emphasizing the need for larger studies and histopathological confirmation for comprehensive validation.

Conclusion

In conclusion, this study underscores the crucial role of Magnetic Resonance Imaging (MRI) in diagnosing and categorizing vertebral collapse etiologies. With a focus on demographic trends, osteoporotic fractures emerged as the most prevalent, particularly in the 41-60 age group. The study's robust statistical analysis established specific MRI features with significant p-values for distinguishing between malignant, osteoporotic, and infective fractures. Notably, features like epidural mass and paraspinal abscess demonstrated 100% specificity in certain cases. Despite limitations, such as a relatively small sample size, this research establishes MRI as a non-invasive and reliable modality for early diagnosis and management, addressing the shortcomings of other imaging techniques. In summary, Magnetic Resonance Imaging plays a definitive role in determining the aetiology of vertebral collapse, providing valuable insights for clinical decision-making.

Ethical approval: The study was approved by the Institutional Ethics Committee

References

1. Lim J, Choi SW, Youm JY, Kwon HJ, Kim SH, Koh HS. Posttraumatic Delayed Vertebral Collapse: Kummell's Disease. J Korean Neurosurg Soc. 2018 Jan; 61(1):1-9.
2. Jeon I, Kim SW, Yu D. Paraspinal muscle fatty degeneration as a predictor of progressive vertebral collapse in osteoporotic vertebral compression fractures. Spine J. 2022 Feb; 22(2):313-320.
3. DeSai C, Reddy V, Agarwal A. Anatomy, Back, Vertebral Column. 2023 Aug 8. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan.
4. Waxenbaum JA, Reddy V, Williams C, Futterman B. Anatomy, Back, Lumbar Vertebrae. 2023 Jul 30. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan.
5. Prost S, Pesenti S, Fuentes S, Tropiano P, Blondel B. Treatment of osteoporotic vertebral fractures. Orthop Traumatol Surg Res. 2021 Feb; 107(1S):102779.
6. Sözen T, Özışık L, Başaran NÇ. An overview and management of osteoporosis. Eur J Rheumatol. 2017 Mar; 4(1):46-56.
7. Matzaroglou C, Georgiou CS, Panagopoulos A, Assimakopoulos K, Wilke HJ, Habermann B, Panos G, Kafchitsas K. Kümmell's Disease: Clarifying the Mechanisms and Patients' Inclusion Criteria. Open Orthop J. 2014 Sep 15; 8:288-97.
8. Bloom BR, Atun R, Cohen T, et al. Tuberculosis. In: Holmes KK, Bertozzi S, Bloom BR, et al., editors. Major Infectious Diseases. 3rd edition. Washington (DC): The International Bank for Reconstruction and Development / the World Bank; 2017 Nov 3. Chapter 11. Available from: https:// www.ncbi.nlm.nih.gov/books/NBK525174
9. Tsukamoto S, Kido A, Tanaka Y, Facchini G, Peta G, Rossi G, Mavrogenis AF. Current Overview of Treatment for Metastatic Bone Disease. Curr Oncol. 2021 Aug 29; 28(5):3347-3372.
10. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021 May; 71(3):209-249.
11. Jeon I, Kim SW, Yu D. Paraspinal muscle fatty degeneration as a predictor of progressive vertebral collapse in osteoporotic vertebral compression fractures. Spine J. 2022 Feb; 22(2):313-320.
12. Muratore M, Ferrera A, Masse A, Bistolfi A. Can We Predict the Progression of Vertebral Collapse in Conservative Treatment of Osteoporotic Vertebral Fractures? A 3-Year Retrospective Study of 180 Patients from the Emergency Department. Int J Spine Surg. 2020 Aug; 14(4):641-648.

13. Zhang X, Xu H, Li GH, Long MT, Cheung CL, Vasan RS, Hsu YH, Kiel DP, Liu CT. Metabolomics Insights into Osteoporosis through Association with Bone Mineral Density. J Bone Miner Res. 2021 Apr; 36(4):729-738.
14. Naaz S, Wahab S, Ekramullah, Sherwani MKA. Diffusion-weighted Magnetic Resonance Imaging in Non-traumatic Vertebral Collapse: A Relook Into Its Utility in Making the Diagnosis in a Population Where Infections of Spine Are a Common Cause. J Med Imaging Radiat Sci. 2018 Mar; 49(1):90-96.
15. Baur A, Stäbler A, Brüning R, Bartl R, Krödel A, Reiser M, Deimling M. Diffusion-weighted MR imaging of bone marrow: differentiation of benign versus pathologic compression fractures. Radiology. 1998 May; 207(2):349-56.
16. Lener S, Hartmann S, Barbagallo GMV, Certo F, Thomé C, Tschugg A. Management of spinal infection: a review of the literature. Acta Neurochir (Wien). 2018 Mar; 160(3):487-496.
17. Kim GU, Chang MC, Kim TU, Lee GW. Diagnostic Modality in Spine Disease: A Review. Asian Spine J. 2020 Dec; 14(6):910-920.
18. Abdel-Wanis ME, Solyman MT, Hasan NM. Sensitivity, specificity and accuracy of magnetic resonance imaging for differentiating vertebral compression fractures caused by malignancy, osteoporosis, and infections. Journal of orthopaedic surgery (Hong Kong). 2011; 19(2):145-50.
19. An HS, Andreshak TG, Nguyen C, Williams A, Daniels D. Can we distinguish between benign versus malignant compression fractures of the spine by magnetic resonance imaging? Spine.1995; 20(16):1776-82.
20. Baur A, Stabler A, Arbogast S, Duerr HR, Bartl R, Reiser M. Acute osteoporotic and neoplastic vertebral compression fractures: fluid sign at MR imaging. Radiology. 2002; 225(3):730-5.