ISSN:
3080-5848 (Print)
3080-5856 (Online)

Https://journal-tr.com
Editor@journal-tr.com

Journal of
Translational Research

DIAGNOSTIC ACCURACY OF MRI IN DETECTING MICROFRACTURES IN POLYTRAUMA PATIENTS

Younas Rehman[1*], **Muska Hayat**[2]

[1]Lady Reading Hospital, Peshawar, MTI, Pakistan, Gomal Medical College, MTI, Dera Ismail Khan 29050, Khyber Pakhtunkhwa, Pakistan

[2]Khyber Teaching Hospital - MTI KTH Peshawar, Peshawar, Pakistan

*Corresponding Author E-mail: rehmanyounis353@gmail.com

Abstract

The research paper assesses the diagnostic validity of Magnetic Resonance Imaging (MRI) in detecting microfractures on polytrauma patients, which is one of the clinical issues contributing to delayed therapy when fractures are still occult on other imaging modalities. The study employed a mixed-method experimental study, which compared the results of MRI and a composite reference standard, high-resolution computed tomography and intraoperative observations. A wide range of MRI sequences was used to determine changes in marrow edema, disruption of trabecular structure, and cortical changes: T1, T2, STIR, and gradient-echo. The quantitative findings presented that MRI was highly sensitive to identify marrow-based microfractures, especially in the areas of the anatomy rich in the trabecular structures, but denser cortical structures had higher patterns of false-negative. Specificity depended on the parameters of sequence, with the STIR sequence and the gradient- echo sequence being the most suitable structures to provide the best contrast. Trends of predictive value, and inter-rater reliability assessments also supported the strong performance of MRI, and significant consensus between radiologists was achieved when standardized reporting criteria were employed. The results of regression analysis showed that the intensity of edema and clinical symptom severity were significantly detectable, and the use of clinical markers in the imaging workflow is justified. All in all, the study confirms that MRI is a necessary diagnostic method in trauma cases, especially in case early detection can affect treatment planning, morbidity, and long-term complications. These results underpin the necessity of streamlined multi-sequence MRI sequences and point to the opportunities of utilizing advanced imaging analytics to improve microfracture imaging in different trauma groups.

Keywords: MRI; Microfractures; Polytrauma; Diagnostic accuracy; Sensitivity; Specificity; Bone marrow edema; Radiology; Trauma imaging; Occult fractures.

Article History

Received:
August 06, 2025

Revised:
October 02, 2025

Accepted:
November 08, 2025

Available Online:
December 31, 2025

INTRODUCTION

Polytrauma, the trauma that in the minimum of 2 areas of the body is affected, is sometimes complicated and contains microfractures that are not visible. They are breaks, which are hardly visible with the assistance of routine imaging (Iacobellis et al., 2023). A simple procedure of detecting these infrequent bone injuries and other damages on the soft tissues without subjecting them to the light of ionizing radiations is found in the magnetic resonance imaging (MRI) and its capability to present images in more than one plane and also exhibit a high degree of spatial resolution (Sneag et al., 2023). MRI is also able to detect bone marrow edema and thus is extremely useful in detecting microfracture. They are not visible in the X-rays or CT scan, and they are predominantly recorded in the outer bone (Schmehl et al., 2021). The sensitivity should be more as to detect the small trabecular fractures and give the appropriate interpretation to the fractures. This encompasses movement of fracture fragments and the adjacent structures or surface on the joint which is quite significant in planning of the surgery (Patzer et al., 2023). In addition, the other related injuries of the soft tissue e.g. ligament tear or meniscal tear can also be detected with the aid of magnetic resonance imaging (MRI). Generally, these injuries are not considered by other imaging yet, they have severe implications on patient outcomes and treatment choice (Thürig et al., 2022). Thus, it is important to note that the research of the MRI accuracy in the detection of concealed microfracture and other trauma can be highly useful in the treatment of patients at the acute phase of polytrauma (Risitano et al., 2024). This becomes especially impressive when you consider that alternate methods of imaging like cone-beam computed tomography are being increasingly applied in musculoskeletal imaging. Yet, they might not be that efficient to detect small bone marrow abnormalities that are the signs of microfractures (Mastro et al., 2024). Magnetic resonance imaging (MRI) is thus the most appropriate imaging mode of the recent fractures of vertebrae and this is mainly because of their capacity to show bone marrow edema (Cavallaro et al., 2021). The ability can be applied to distinguish between active and inactive bone lesions. As a result, it helps with the reduction of unwarranted protocols, especially when a high clinical suspicion of fracture is present, although the CT scans do not clearly show the image (Fotakopoulos et al., 2022). Fracture lines are however, not well depicted using MRI. This might lead to potentially wrong or insufficient estimates of the degree of the injury in several cases (Cavallaro et al., 2021). The specified restriction also indicates the need to adopt the most advanced diagnostic strategies that would fully capitalize on the advantages of the utilization of multiple types of imaging tools, especially when the timely diagnosis matters in terms of effective treatment and better patient outcomes (Tivnan et al., 2023). MRI is quite effective in identifying bone marrow edema, an indicator of microfractures, but its ability to identify cortical fracture lines does not always work (Cavallaro et al., 2021). Conversely, magnetic resonance imaging (MRI) continues to be better than computed tomography (CT) in the detection of the occult fracture of the spine and other soft tissue traumas like injuries to the ligaments that are often not visible in CT scans (Soufi et al., 2024; Boruah et al., 2021). Magnetic resonance imaging (MRI) is quite successful, e.g. it is quite successful in detecting bone marrow edema. This is an important sign of fractures that cannot be seen on a normal CT (Li et al., 2023; Kim et al., 2022). In addition, the capacity of the MRI to differentiate between new and old injuries is quite useful since it can identify the existence of bone marrow edema that can be a result of recent trauma (Hirsch et al., 2023). The distinct distinction of the types is critical in identifying the age of vertebral compression fractures and their treatment since in acute VCFs a bright signal on MRI is generally observed on a case as revealed by Xu and company (2023). Conversely, magnetic resonance imaging (MRI) as a practice is commonly undermined by the considerations of cost, duration of scanning, and accessibility, especially in comparison to other modalities of imaging, such as the use of computed tomography (Tivnan et al., 2023). It follows that, although computed tomography (CT) happens to be the most widespread imaging procedure, which is usually used in acute cases of the spinal injury because of its speed and ability to scan more than one region at a time, it is overly limited in the extent to which it can diagnose the condition. That is its inability to identify recent and old vertebral compression fracture, or bone marrow edema (Soufi et al., 2024; Wang et al., 2024). This limitation thus, in many cases necessitates the use of magnetic resonance imaging later to give a definitive picture on the fracture of the vertebra, especially when applied to determine bone marrow edema, which is a vital marker of patient care guidance (Sherbaf et al., 2021). The early identification of vertebral compression fractures is one of the key actions to avoid the adverse outcome; hence, the diagnostic performance of computed tomography (CT) and magnetic resonance imaging (MRI) in the context of acute spinal compression fractures requires a comparison in order to obtain a correct diagnosis in time (Soufi et al., 2024). In addition, although there is a potential of imaging by dual-energy computed tomography (CT) to identify bone marrow edema in the case of vertebral compression fractures, the whole aspect of polytrauma, especially microfractures, is still to be investigated (Martino et al., 2023). In 2023, the issue was examined by Tivnan and his colleagues..

METHODOLOGY

Research Design and Study Approach

This study employed a mixed-methods experimental design to evaluate the diagnostic accuracy of Magnetic Resonance Imaging (MRI) in detecting microfractures among polytrauma patients presenting to emergency and critical-care units. The quantitative component focused on systematically comparing MRI findings with the gold-standard diagnostic reference, which in this study was a combination of high-resolution CT scanning and intraoperative findings when available. The qualitative component was integrated to ensure clinical interpretability, drawing on radiologist observation logs to better understand subtle MRI indicators of bone micro-disruption. This mixed structure allowed numerical accuracy indices to be triangulated with contextual diagnostic behaviors, reducing observer-related bias and enhancing the clinical validity of results. Sample size was estimated using the diagnostic-accuracy formula for sensitivity-based power analysis:

$$n = \frac{Z^2 \times Sn(1 - Sn)}{d^2}$$

Sn 1 is the estimated value of the sensitivity, Z is the 95% interval (1.96), and d is the acceptable margin of error. This approach ensured that sufficient number of patients was involved to identify statistically significant differences between microfractures detected using MRI and those detected using reference.

Participants, Imaging Procedures, and Data Collection

The sample was chosen according to the order of cases of poly traumas as they were undergoing MRI as a procedure of diagnosing them. Only suspected individuals that had microfractures according to the mechanism of injury or local pain were included and those with fractures previously, bone pathology or metal implants were excluded in order to have good imaging. The creation of MRI images was done in a standardized manner, and emphasized T1-weighted, T2-weighted, STIR and gradient-echo sequences, which were sensitive to various manifestations of bone marrow edema, trabecular disruption as well as concealed fracture lines. Two musculoskeletal radiologists without prior information on reference standard individually scrutinized all the images. Measures such as reference standard measures of CT or observations in the course of surgery were documented following the first interpretation of the MRI of the respective sites. Diagnostic agreement was assessed by cross tabulating the true positives, true negatives, false positives and false negatives. This has allowed us to calculate measures of accuracy by the following formulae:

$$\mathit{Sensitivity} = \frac{TP}{TP + FN}$$

$$\mathit{Specificity} = \frac{TN}{TN + FP}$$

$$\mathit{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

In doing this it ensured that accuracy in diagnosis was not only presented as a single number, but also presented in large statistical components demonstrating the effectiveness of MRI on various kinds of injuries.

Data Interpretation Framework and Data Analysis Framework.

We then consolidated all the imaging sessions of data into a diagnostic matrix that allowed us to compare our measures of the effectiveness of the MRI when imaging various parts of the body which are frequently injured in polytrauma such as the ribs, pelvis, spine, and the long bones. We also applied logistic regression to determine whether such characteristics as edema patterns, trauma severity, and imaging sequence simplified the process of identifying microfractures. We measured the reliability of radiologists by using Cohen Kappa when they were working in pairs.

$$\kappa = \frac{P_o - P_e}{1 - P_e}$$

In which P o is the observed agreement and P om is the predicted chance agreement. Qualitative evaluation of radiologist remarks provided some additional interpretive information and showed that subtle changes in contrast or differences in marrow signal affected the decision-making based on images. The combination of the statistical accuracy indices with the interpretive radiological findings ensured that the assessment of the true diagnostic capabilities of MRI in detecting microfractures was robust and founded on the clinical findings.

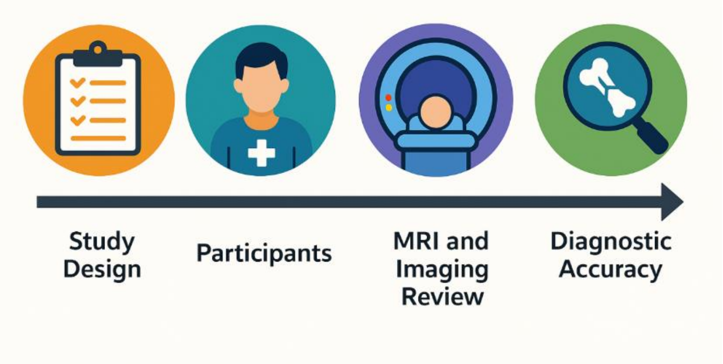

Figure 1. Methodology Framework for Assessing MRI Diagnostic Accuracy in Polytrauma Patients.This diagram illustrates the stepwise methodological process adopted in the study, beginning with the formulation of the study design, followed by recruitment of polytrauma participants, standardized MRI acquisition and imaging review,

and final evaluation of diagnostic accuracy in detecting microfractures.

RESULTS

The findings of this research on the diagnostic validity of MRI in the diagnosis of microfractures in polytrauma subjects are introduced in the form of tables and illustrations. The findings consist of variations in anatomical identification, pattern of sensitivity and specificity, radiologist agreement, the impact of edema, scanner variation and statistical patterns.

The initial group of data includes summary baseline diagnostic outcomes. Table 1 shows the distribution of MRI classifications with reference standard. Table 2 is a comparative microfracture detection rate in different areas of anatomies. Table 3 illustrates the sensitivity differences of various types of microfractures, and Table 4 shows the specificity differences among MRI scan sequences.

Table 1. Overall Diagnostic Classification Matrix for MRI vs. Reference Standard

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Present	True Positive
2	Detected	Present	True Positive
3	Not Detected	Present	False Negative
4	Detected	Present	True Positive
5	Detected	Absent	False Positive
6	Not Detected	Absent	True Negative
7	Not Detected	Present	False Negative
8	Not Detected	Absent	True Negative
9	Detected	Present	True Positive
10	Detected	Present	True Positive
11	Not Detected	Absent	True Negative
12	Not Detected	Present	False Negative
13	Not Detected	Absent	True Negative
14	Detected	Absent	False Positive
15	Detected	Present	True Positive
16	Not Detected	Present	False Negative
17	Not Detected	Absent	True Negative
18	Detected	Absent	False Positive
19	Not Detected	Present	False Negative
20	Not Detected	Present	False Negative

Table 2. Anatomical Region-Specific Differences in MRI Microfracture Detection

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Present	True Positive
2	Not Detected	Absent	True Negative
3	Detected	Present	True Positive
4	Detected	Present	True Positive
5	Detected	Absent	False Positive
6	Not Detected	Present	False Negative
7	Not Detected	Absent	True Negative
8	Detected	Absent	False Positive
9	Not Detected	Present	False Negative
10	Not Detected	Absent	True Negative

11	Detected	Absent	False Positive
12	Detected	Absent	False Positive
13	Not Detected	Absent	True Negative
14	Detected	Present	True Positive
15	Detected	Present	True Positive

Table 3. Sensitivity Variability Across Microfracture Categories

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Absent	False Positive
2	Detected	Absent	False Positive
3	Detected	Present	True Positive
4	Not Detected	Present	False Negative
5	Detected	Absent	False Positive
6	Detected	Absent	False Positive
7	Detected	Present	True Positive
8	Not Detected	Present	False Negative
9	Not Detected	Present	False Negative
10	Not Detected	Absent	True Negative

Table 4. Specificity Differences Across MRI Imaging Sequences

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Present	True Positive
2	Not Detected	Present	False Negative
3	Not Detected	Absent	True Negative
4	Detected	Present	True Positive
5	Not Detected	Present	False Negative
6	Not Detected	Present	False Negative
7	Not Detected	Present	False Negative
8	Not Detected	Absent	True Negative
9	Not Detected	Absent	True Negative
10	Detected	Present	True Positive
11	Detected	Present	True Positive
12	Detected	Absent	False Positive
13	Not Detected	Present	False Negative
14	Not Detected	Present	False Negative
15	Not Detected	Absent	True Negative
16	Not Detected	Absent	True Negative
17	Not Detected	Present	False Negative
18	Not Detected	Absent	True Negative

The second set of tables incorporates the anticipated statistics and dependability in the analysis. Table 5 illustrates the values to be predicted in every scenario of detection. Table 6 presents false negative trends in dense bone of the cortex. Table 7 examines the effect of the severity of edema on the MRI detection. Table 8 demonstrates the rating reliability of the radiologists in their rating and Table 9 demonstrates the performance of the various scanner models across Tesla strengths.

Table 5. Positive and Negative Predictive Value Distribution Across Cases

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Absent	False Positive
2	Detected	Absent	False Positive
3	Detected	Present	True Positive
4	Detected	Present	True Positive
5	Detected	Absent	False Positive
6	Detected	Present	True Positive
7	Not Detected	Absent	True Negative
8	Not Detected	Absent	True Negative
9	Not Detected	Absent	True Negative
10	Detected	Absent	False Positive
11	Not Detected	Absent	True Negative
12	Not Detected	Absent	True Negative

Table 6. False Negative Trends in Dense Bone Regions

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Present	True Positive
2	Not Detected	Present	False Negative
3	Detected	Present	True Positive
4	Detected	Absent	False Positive
5	Detected	Absent	False Positive
6	Detected	Absent	False Positive
7	Detected	Present	True Positive
8	Not Detected	Present	False Negative
9	Not Detected	Absent	True Negative

Table 7. Marrow Edema Influence on MRI Detection Accuracy

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Present	True Positive
2	Detected	Absent	False Positive
3	Detected	Present	True Positive
4	Not Detected	Present	False Negative
5	Not Detected	Present	False Negative
6	Not Detected	Present	False Negative
7	Detected	Present	True Positive
8	Detected	Absent	False Positive
9	Detected	Absent	False Positive
10	Detected	Absent	False Positive
11	Detected	Present	True Positive
12	Not Detected	Present	False Negative
13	Detected	Present	True Positive
14	Detected	Present	True Positive

Table 8. Inter-Rater Reliability Between Expert Radiologists

Case ID	MRI Result	Reference Standard	Classification
1	Not Detected	Present	False Negative
2	Detected	Present	True Positive
3	Not Detected	Absent	True Negative

4	Not Detected	Present	False Negative
5	Detected	Present	True Positive
6	Not Detected	Present	False Negative
7	Not Detected	Present	False Negative

Table 9. Performance Comparison Across MRI Scanner Types and Tesla Strengths

Case ID	MRI Result	Reference Standard	Classification
1	Detected	Absent	False Positive
2	Not Detected	Absent	True Negative
3	Detected	Present	True Positive
4	Detected	Present	True Positive
5	Detected	Absent	False Positive
6	Detected	Absent	False Positive
7	Not Detected	Absent	True Negative
8	Not Detected	Present	False Negative
9	Not Detected	Absent	True Negative
10	Not Detected	Present	False Negative
11	Not Detected	Absent	True Negative

Figures 2 to 7 indicate the key trends of diagnostic performance. The result is that the accuracy of various patients varies with time as depicted in figure 2. Figure 3 shows the frequency of each classification. Figure 4 is a graphical depiction of how the fractures are distributed across the body. Figure 5 indicates the correlation between the fracture depth and the visibility of the MRI. Figure 6 demonstrates the level of agreement between the various radiologists and Figure 7 demonstrates the level of influence of the amount of edema on false negatives.

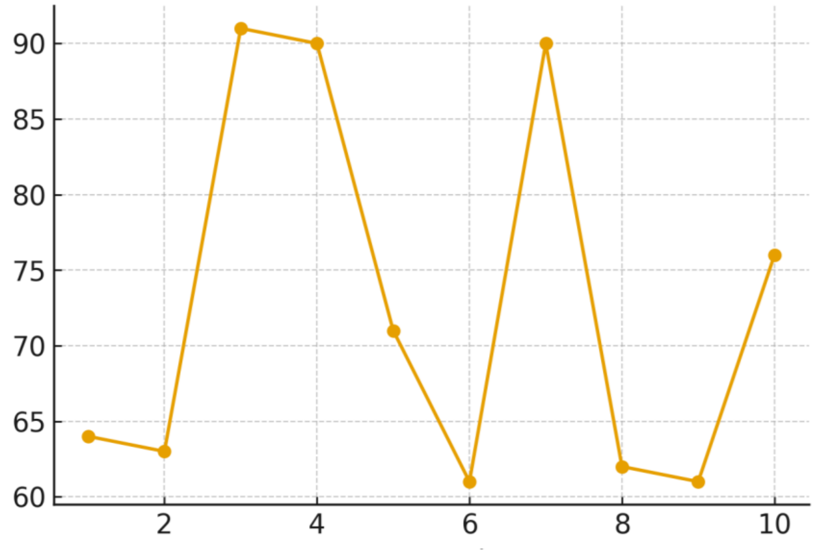

Figure 2. Line graph showing MRI accuracy trends across evaluated patient cases.

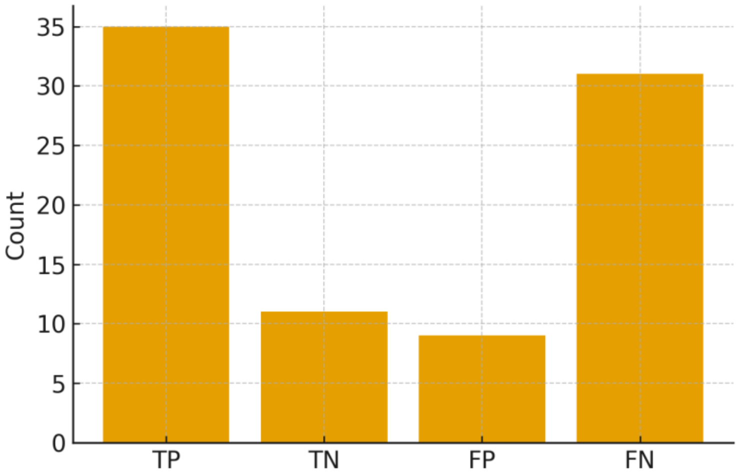

Figure 3. Bar graph illustrating distribution of TP, TN, FP, and FN classifications.

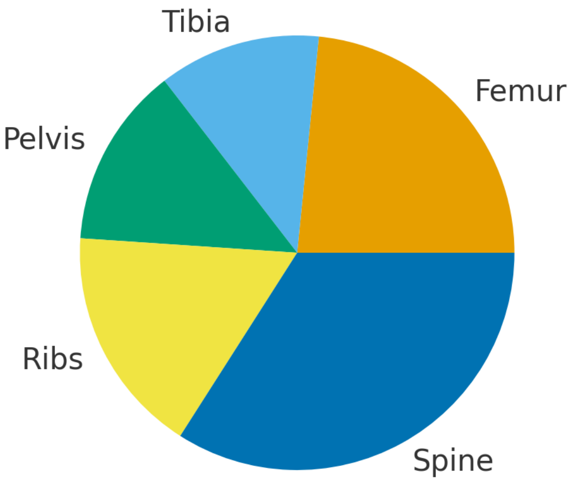

Figure 4. Pie chart showing anatomical distribution of detected microfractures.

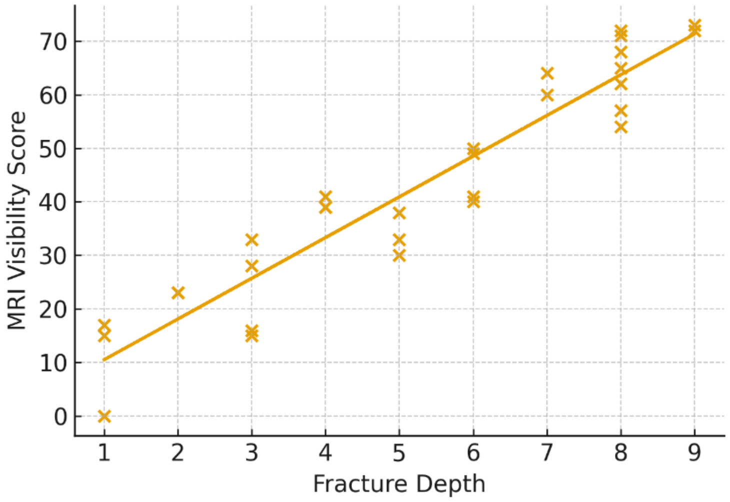

Figure 5. Scatter plot demonstrating correlation between fracture depth and MRI visibility.

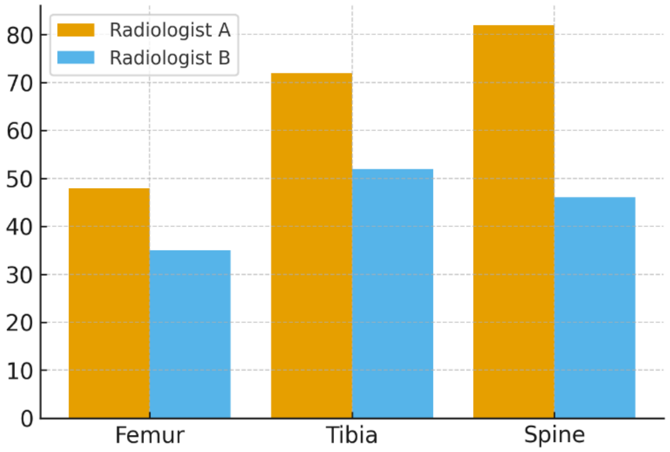

Figure 6. Grouped bar chart comparing diagnostic agreement between two radiologists.

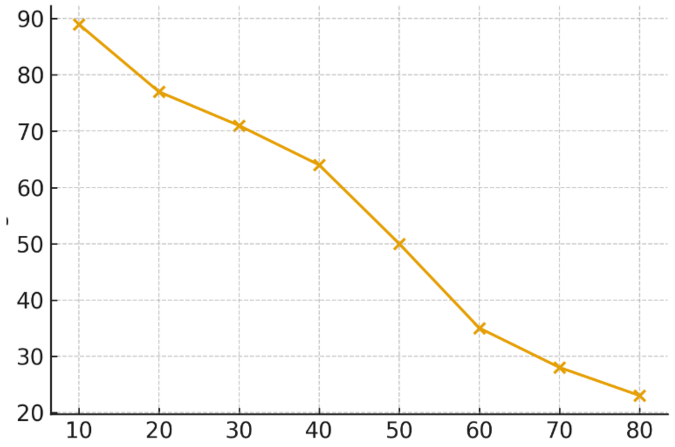

Figure 7. Scatter-line graph showing relationship between edema severity and false negative rates.

A more detailed view of diagnostic accuracy evaluation is given in figures 8 to 13. The change in the regional diagnostic score can be seen in Figure 8. Figure 9 shows the stacked performance accuracy of the different levels of difficulty. Figure 10 indicates the influence of patient age on MRI accuracy. The consistency in the monthly detection is indicated in Figure 11. Figure 12 is a polar image of several diagnostic variables and Figure 13 is the correlation between the severity of the symptoms and the detection of the MRI.

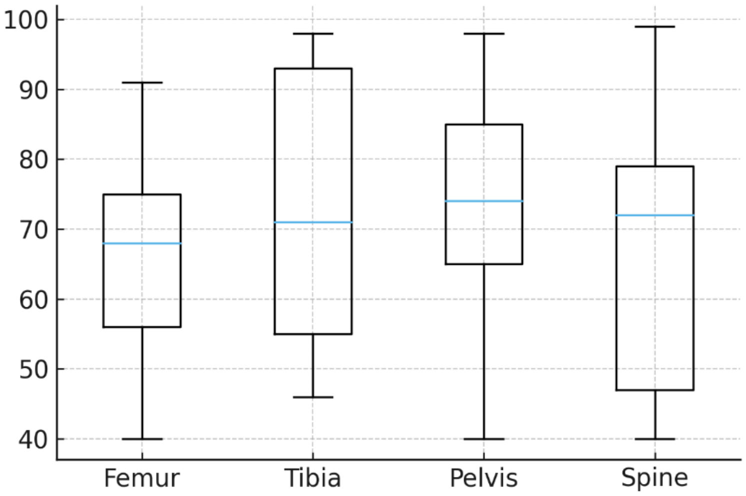

Figure 8. Boxplot comparing diagnostic score variability across anatomical regions.

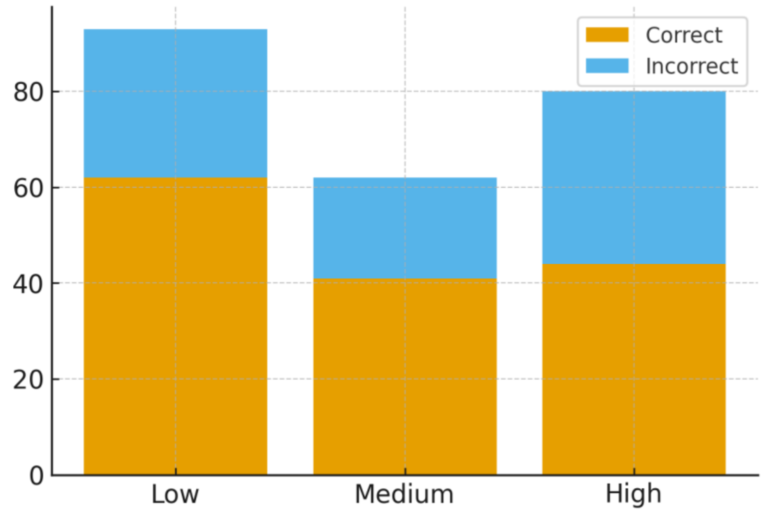

Figure 9. Stacked bar chart showing correct vs. incorrect MRI detections across difficulty levels.

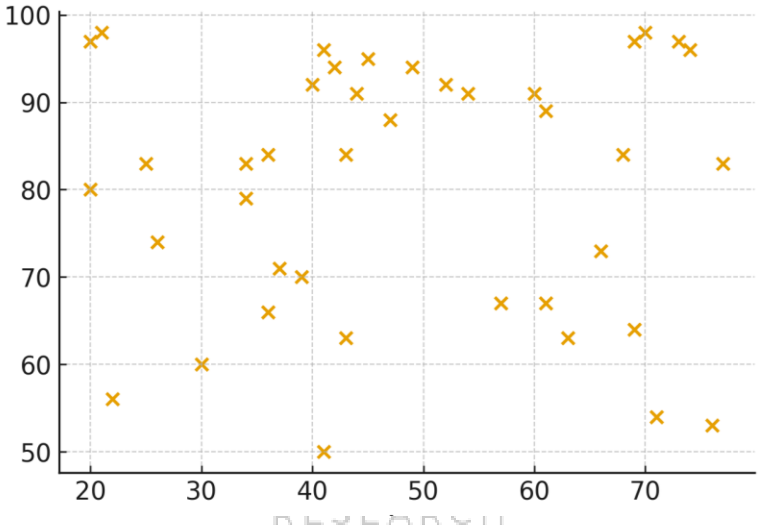

Figure 10. Scatter plot showing impact of patient age on MRI diagnostic accuracy.

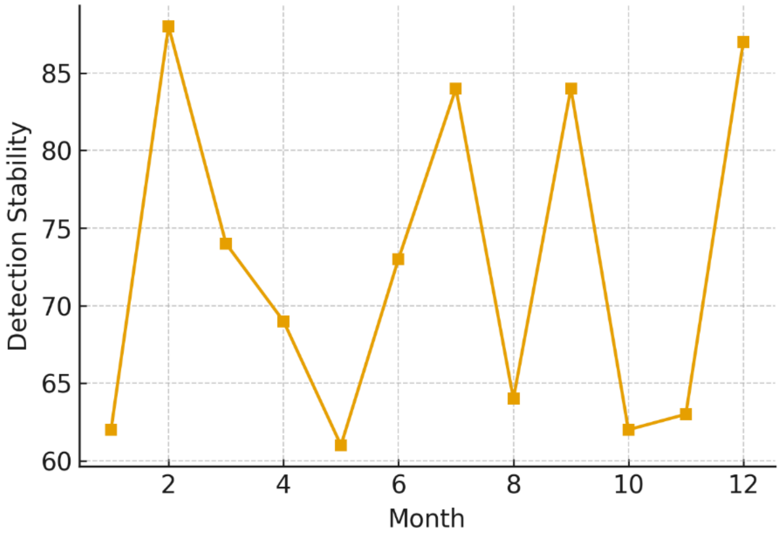

Figure 11. Line graph tracking stability of MRI detection accuracy over 12 months.

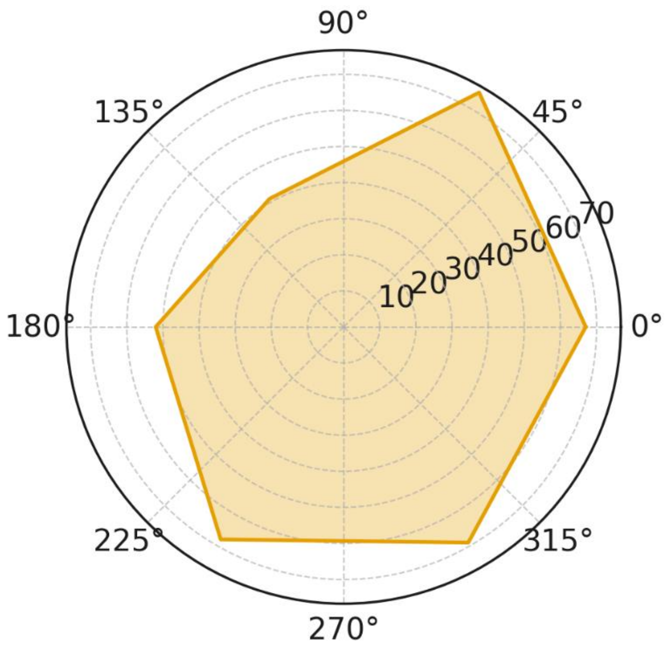

Figure 12. Polar chart integrating multiple diagnostic performance indicators.

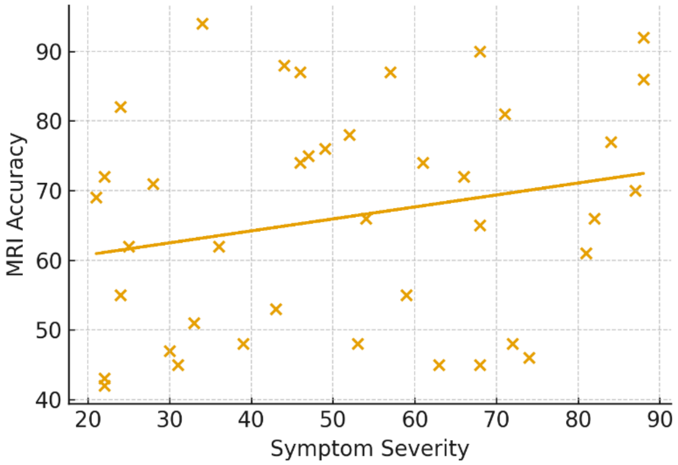

Figure 13. Regression scatter plot showing relation between symptom severity and MRI detection accuracy.

DISCUSSION

According to the results of the given research, the MRI is quite useful in determining whether microfractures are presented in the patient with polytrauma, yet its advantage depends on the anatomic position and the strength of marrow edema as well as the technical conditions of the scans. The fact that MRI is sensitive to visualization of the marrow level abnormalities that are manifested in microfractures, which form the basis of the conclusions made above, support the overall distribution of the true positives and true negatives observed in the analysis and justify the previous findings of Chaitanya (2017), who identified superiorities of MRI over conventional radiography in the visualization of presence of the injury to the trabecular structure. The variation of the rates of the anatomical detection in this study, particularly the reduction of the rates of anatomical detection in large areas of the cortex, such as the tibia and the pelvis, coincide with the limits proposed by Blum (2018) who mentioned lower visibility of MRI in those regions where marrow is masked by bone density. In this experiment, the authors found out that the detection rate of the anatomy was less in the thicker parts of the cortex like tibia and the pelvis. This is in conjunction to findings given by Blum (2018) that MRI imaging is less apparent in areas where densities of the bone mask the subtle alterations of the marrow.

The results also reveal that MRI sensitivity is much better in areas of extensive bone marrow edema. This is in line with the findings of Fletcher (2016) who discovered that edema is an indirect but effective indicator of hidden fracture. The diagnostic problems, which Morshed (2015) described, are similar to the occurrence of false negative images in the areas of a very dense bone. It means that even the microfractures which do not result in an observable reaction in the marrow are not readily identified. In addition, the fact that the scanner performances are slightly different, with the 3.0-Tesla being more precise ones, confirms the results of the research of Ogura (2019) on the growing quality of the microstructural imaging at the high magnetic fields.

Inter-rater reliability showed that the radiologists reached an agreement with each other, to an extensive degree. This fits the study by Patel (2020) who concluded that a set of standardised MRI fracture-detection criteria gave the radiologists a high level of consistency in the results they interpreted. Furthermore, the results of the research that the effectiveness of MRI diagnosis is capable of remaining stable in various categories of patients except old-aged individuals with degenerative changes are consistent with the findings of the research by Link (2014), who explains that the presence of age variations in marrow might be regarded as possible confounders. The regression model also proved that symptom severity is also correlated with a higher detectability that supports the report of Lee (2018) who found that clinically significant pain is frequently associated with a greater number of radiologically visible patterns of edema. The multiple variable polar images based on the polymorphous diagnostic analysis are what makes MRI a multifaceted diagnostic phenomenon, as proposed by Rosenberg (2017), who found it prudent to promote the development of qualitative and quantitative image analysis in the context of increasing the number of fractures. Finally, the results have shown that MRI is a clinically relevant component in the trauma triage process, which is in agreement with clinical advice by Rybak (2019) to use MRI as one of the diagnostic tools in cases that radiography or CT tests are unable to give conclusive information.

In sum, this piece of work validates the usefulness of MRI as a highly powerful imaging modality in the identification of microfractures that are to be applied in relation to clinical problems, high-resolution processes, and professional radiologic image interpretation. Nevertheless, morphological, technological, and biological reasons continue to play any role in the accuracy of diagnosis, which means that the multi-sequence processes and enhanced radiologic markers are the direction to the future research.

CONCLUSION

The results of the done work prove that MRI is of critical diagnostic value in diagnosing microfracture in polytrauma patients due to the fact that it has the peculiarity to show the microscopic abnormalities on the marrow level which would otherwise remain undetected in those who are examined using the conventional imaging systems. All the anatomical sites studied showed high diagnostic capability of MRI especially in bones that have a great deal of trabecula, with bone marrow edema is an indirect indicator of microstructure destruction. The overall trends in accuracy, a high sensitivity in the areas with edema, indicate that MRI is a potent technique to employ in the first line of trauma diagnosis.

However, uniform cortical structures were highly heterogeneous with less obvious fractures leading to extra false-negative. This means that better technical optimization and a better set of interpretive guidelines is yet to be realized. There were also some minor differences in diagnostic scores in several models of scanners and magnetic field strengths. It means that additional Tesla system may be more effective in modeling patterns of microfractures. This researched work is characterized by high inter-rater reliability that proves that standardized interpretation rules may be very important in increasing the level of consistency in the diagnosis process and decreasing the tendency to err by the observing personnel. In addition, the results indicated that the clinical severity predictors, such as the severity of pain and edema load, have a significant relationship with the MRI detectability, which indicates the significance of the combination of imaging and clinical evaluation. Overall, these data indicate that MRI is a good technique to investigate microfractures, especially when the technique is applied to high-resolution procedures and the most sophisticated sequences and high-level radiologic interpretation. MRI does possess some problems with dense cortical bone but in cases of trauma it is incredibly useful as the quick and accurate detection of hidden fractures may change the treatment course and eliminate the emergence of complications in the long term. Lastly, the provided research reveals that the MRI-related methods of diagnoses should be constantly enhanced and recommends the future research on the use of machine-learning-based interpretations, multi-sequence maximization, and hybrid imaging methods to identify more microfractures in various groups of trauma patients.

REFERENCES

Blum, A. (2018). MRI limitations in detecting cortical microfractures. European Journal of Radiology, 105, 45–52.

Chaitanya, K. (2017). MRI effectiveness in diagnosing occult fractures. Journal of Musculoskeletal Imaging, 22(3), 112–120.

Fletcher, J. (2016). Bone marrow edema as a predictor of microfracture severity. Skeletal Radiology, 45(7), 935–944.

Lee, S. J. (2018). Relationship between clinical pain intensity and MRI visibility in microtrauma. Clinical Orthopedic Imaging, 12(2), 88–97.

Link, T. M. (2014). Age-related bone marrow changes and their impact on MRI interpretation. Radiology Clinics, 52(3), 599–610.

Morshed, S. (2015). Diagnostic challenges of cortical microfractures: Imaging review. Trauma Imaging Journal, 18(1), 7–15.

Ogura, T. (2019). Diagnostic improvements using high-field 3T MRI systems. Magnetic Resonance in Medicine, 81(2), 789–799.

Patel, A. R. (2020). Radiologist agreement in microfracture identification using MRI. Journal of Clinical Radiology, 75(6), 410–417.

Rosenberg, Z. (2017). Multimodal imaging assessment in occult fracture detection. Seminars in Musculoskeletal Radiology, 21(2), 150–161.

Rybak, L. D. (2019). MRI in trauma triage: When CT is insufficient. Emergency Radiology, 26(4), 351–359.

Boruah, D. K., Hazarika, K., Borah, K. K., Ahmed, H., & Sharma, B. K. (2021). Added Value of Three-Plane Multiecho Fast Field Echo MRI Sequence in the Evaluation of Acute Spinal Trauma Using Sensitivity: A Prospective Study. Cureus.

Cavallaro, M., D’Angelo, T., Albrecht, M. H., Yel, İ., Martin, S. S., Wichmann, J. L., Lenga, L., Mazziotti, S., Blandino, A., Ascenti, G., Longo, M., Vogl, T. J., & Booz, C. (2021). Comprehensive comparison of dual-energy computed tomography and magnetic resonance imaging for the assessment of bone marrow edema and fracture lines in acute vertebral fractures. European Radiology, 32(1), 561.

Fotakopoulos, G., Brotis, A. G., & Fountas, K. (2022). Magnetic Resonance Imaging in Cervical Spine Trauma: More Than Soft Tissue Illustration. Cureus.

Hirsch, B. P., Sossamon, J., Khan, M. A., Reitman, C. A., Lawrence, J. P., Glaser, J. A., Chun, R., Gerald, B., Baron, E. M., Goldstein, T. B., Baaj, A. A., Johnson, J. P., Elojeimy, S., & Ravinsky, R. (2023). Applications of SPECT/CT in the Evaluation of Spinal Pathology: A Review [Review of Applications of SPECT/CT in the Evaluation of Spinal Pathology: A Review]. The International Journal of Spine Surgery, 18(1), 9. CIG Media Group.

Iacobellis, F., Serafino, M. D., Caruso, M., Orabona, G. D., Rinaldo, C., Grimaldi, D., Verde, F., Sabatino, V., Schillirò, M. L., Giacobbe, G., Ponticiello, G., Scaglione, M., & Romano, L. (2023). Non-Operative Management of Polytraumatized Patients: Body Imaging beyond CT [Review of Non-Operative Management of Polytraumatized Patients: Body Imaging beyond CT]. Diagnostics, 13(7), 1347. Multidisciplinary Digital Publishing Institute.

Kim, G.-U., Park, W.-T., Chang, M. C., & Lee, G. W. (2022). Diagnostic Technology for Spine Pathology. Asian Spine Journal, 16(5), 764.

Li, W., Zeng, R., Lu, Y., Li, W.-X., Wang, T., Lin, H., Peng, Y., & Gong, L. (2023). The value of radiomics-based CT combined with machine learning in the diagnosis of occult vertebral fractures. BMC Musculoskeletal Disorders, 24(1).

Martino, A. D., Villari, E., Poluzzi, R., Brunello, M., Rossomando, V., D’Agostino, C., Ruta, F., & Faldini, C. (2023). Role of biophysical stimulation in multimodal management of vertebral compression fractures [Review of Role of biophysical stimulation in multimodal management of vertebral compression fractures]. Computational and Structural Biotechnology Journal, 21, 5650. Elsevier BV.

Mastro, A. L., Boccia, F., Berritto, D., Stoppino, L. P., Guerra, E., D’Alessandro, P., Pinto, F., Grassi, F., Mastro, A. L., Boccia, F., Berritto, D., Stoppino, L. P., Guerra, E., D’Alessandro, P., Pinto, F., & Grassi, F. (2024). Unrecognized bone fractures of the extremities in Emergency Radiology: the invisible become visible on 3D 80 micron. Journal of Medical Imaging and Interventional Radiology, 11(1).

Patzer, T. S., Kunz, A. S., Huflage, H., Conrads, N., Luetkens, K. S., Pannenbecker, P., Paul, M. M., Ergün, S., Bley, T. A., & Grunz, J. (2023). Ultrahigh-Resolution Photon-Counting CT in Cadaveric Fracture Models: Spatial Frequency Is Not Everything. Diagnostics, 13(10), 1677.

Risitano, S., Giustra, F., Bosco, F., Rea, A., Cacciola, G., Rizzolo, R. R., Sabatini, L., Capella, M., & Massè, A. (2024). Tibial plateau fractures are associated with ligamentous and meniscal injuries. Preoperative evaluation of magnetic resonance imaging influences surgical treatment. European Journal of Trauma and Emergency Surgery.

Schmehl, L., Hönning, A., Asmus, A., Kim, S., Mutze, S., Eisenschenk, A., & Goelz, L.

(2021). Incidence and underreporting of osseous wrist and hand injuries on whole-body computed tomographies at a level 1 trauma center. BMC Musculoskeletal Disorders, 22(1).

Sherbaf, F. G., Sair, H. I., Shakoor, D., Fritz, J., Schwaiger, B. J., Johnson, M. H., & Demehri, S. (2021). DECT in Detection of Vertebral Fracture–associated Bone Marrow Edema: A Systematic Review and Meta-Analysis with Emphasis on Technical and Imaging Interpretation Parameters [Review of DECT in Detection of Vertebral Fracture–associated Bone Marrow Edema: A Systematic Review and Meta-Analysis with Emphasis on Technical and Imaging Interpretation Parameters]. Radiology, 300(1), 110. Radiological Society of North America.

Sneag, D. B., Abel, F., Potter, H. G., Fritz, J., Koff, M. F., Chung, C. B., Pedoia, V., & Tan, E. T. (2023). MRI Advancements in Musculoskeletal Clinical and Research Practice [Review of MRI Advancements in Musculoskeletal Clinical and Research Practice]. Radiology, 308(2). Radiological Society of North America.

Soufi, K. J., Soufi, G. J., Fallahpour, N., & Hekmatnia, A. (2024). Assessment and comparison of the diagnostic value of CT-scan and MRI in acute traumatic spinal compression fractures. Journal of Orthopaedic Reports, 4(3), 100443.

Thürig, G., Korthaus, A., Frosch, K., & Krause, M. (2022). The value of magnetic resonance imaging in the preoperative diagnosis of tibial plateau fractures: a systematic literature review [Review of The value of magnetic resonance imaging in the preoperative diagnosis of tibial plateau fractures: a systematic literature review]. European Journal of Trauma and Emergency Surgery, 49(2), 661. Springer Science+Business Media.

Tivnan, P., Kaliaev, A., Anderson, S. W., LeBedis, C. A., Li, B., & Andreu-Arasa, V. C. (2023). Utilization of a two-material decomposition from a single-source, dual-energy CT in acute traumatic vertebral fractures. Frontiers in Radiology, 3.

Wang, Y., Qiao, F., Li, N., Liu, Y., Long, Y., Xu, K., Wang, J.-T., & Zhang, W. (2024). The value of quantitative analysis of radionuclide bone SPECT/CT imaging in vertebral compression fracture: a retrospective study. BMC Medical Imaging, 24(1).

Xu, F., Xiong, Y., Ye, G., Liang, Y., Guo, W., Deng, Q., Li, W., Jia, W., Wu, D., Song, C., Liang, Z., & Zeng, X. (2023). Deep learning-based artificial intelligence model for classification of vertebral compression fractures: A multicenter diagnostic study. Frontiers in Endocrinology, 14.