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RESEARCH ARTICLE
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MAGNETIC RESONANCE IMAGING (MRI) FINDINGS IN LUMBAR DISC DISEASE: CORRELATION WITH ANESTHETIC CHALLENGES AND SURGICAL OUTCOMES"

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Abstract

Background: Lumbar disc disease is a common cause of back pain and radiculopathy, often necessitating surgical intervention. Preoperative assessment using magnetic resonance imaging (MRI) is critical for identifying disc herniation, nerve root compression, spinal canal stenosis, and degenerative changes. These findings not only guide surgical planning but also influence anesthetic management, including the choice between general, regional or combined anesthesia, as well as patient positioning and perioperative risk stratification.

Objectives: The study aimed to assess how preoperative MRI findings in lumbar disc disease influence anesthetic management and surgical outcomes, by evaluating the relationship between MRI pathology and anesthetic complexity, and determining the impact of MRI severity on surgical parameters and postoperative recovery. It emphasized integrating radiological, surgical, and anesthetic evaluations for optimized perioperative care.

Methodology: This prospective observational study included 120 adult patients diagnosed with lumbar disc disease on MRI and scheduled for elective lumbar disc surgery. MRI scans were analyzed for disc level involvement, nerve root compression, multilevel disease, and degenerative changes. Preoperative anesthetic assessment recorded ASA status, comorbidities, and anticipated challenges. Intraoperative data included anesthetic technique, positioning difficulties, hemodynamic instability, and regional block success, while surgical outcomes encompassed duration, blood loss, postoperative recovery time, and pain scores.

Results: The study population had a mean age of 44.2 ± 12.8 years, with 54.2% males. MRI revealed single-level disc herniation in 43.3%, multilevel involvement in 31.7%, nerve root compression in 58.3%, spinal canal stenosis in 20.8%, and degenerative changes in 50% of patients. General anesthesia was administered in 48.3%, regional in 35%, and combined anesthesia in 16.7%. Severe MRI findings, including multilevel disease and significant nerve root compression, were associated with increased anesthetic complexity, higher rates of general or combined anesthesia, difficult positioning, and occasional regional block failure. Surgical duration and intraoperative blood loss increased proportionally with MRI severity, while postoperative recovery time and pain scores were also higher in patients with more severe pathology. **Conclusion:** MRI evaluation in lumbar disc disease provides essential guidance for both surgical and anesthetic planning. Patients with severe or multilevel disc pathology are more likely to present anesthetic challenges and require careful preoperative preparation. Integration of MRI findings into perioperative assessment enhances patient safety, optimizes anesthetic strategies and improves surgical outcomes, emphasizing the importance of multidisciplinary collaboration between radiologists, surgeons and anesthesiologists.

Keywords: Lumbar disc disease; Magnetic resonance imaging; Disc herniation; Nerve root compression; Spinal canal stenosis

INTRODUCTION:

Musculoskeletal disorders constitute a major cause of pain, disability and reduced quality of life worldwide, placing a substantial burden on healthcare systems. Orthopedic conditions such as degenerative joint disease, traumatic injuries, spinal disorders and soft-tissue pathologies frequently require surgical intervention for definitive management[1,2]. Accurate preoperative diagnosis and assessment are essential not only for surgical planning but also for optimizing perioperative anesthetic management and improving patient outcomes.

Magnetic Resonance Imaging (MRI) has emerged as a cornerstone in the diagnostic evaluation of orthopedic conditions due to its superior soft-tissue contrast, multiplanar capability and absence of ionizing radiation[3-5]. MRI allows detailed visualization of bones, cartilage, ligaments, tendons, muscles, intervertebral discs, neural structures and bone marrow, making it the imaging modality of choice for many musculoskeletal pathologies. Radiological MRI findings play a crucial role in determining disease severity, extent of involvement, and surgical complexity, thereby directly influencing clinical decision-making[6].

From an anesthetic perspective, preoperative MRI findings provide valuable information that can affect the choice of anesthetic technique, airway management, patient positioning, and perioperative risk stratification[7-10]. Conditions such as severe spinal stenosis, disc herniation, ligamentous instability, inflammatory changes and extensive soft-tissue involvement may pose challenges for regional anesthesia techniques, neuraxial blocks or safe patient positioning during surgery[11]. Similarly, complex orthopedic trauma and advanced degenerative changes often necessitate prolonged surgical duration, increased blood loss and careful intraoperative monitoring, all of which have important anesthetic implications.

In certain patient populations, including pediatric patients, elderly individuals, and those with severe pain or anxiety, anesthesia or sedation may also be required during MRI acquisition itself to ensure image quality and patient safety[12,13]. This further highlights the close interrelationship between radiological evaluation and anesthetic care in orthopedic practice. Despite this interdependence, the anesthetic implications of specific MRI findings are often underemphasized in routine clinical workflows, and communication between radiologists, orthopedic surgeons, and anesthesiologists may remain suboptimal[14,15].

Previous studies have primarily focused on the diagnostic accuracy of MRI in orthopedic conditions or on anesthetic techniques in orthopedic surgery as separate domains. However, limited literature has systematically examined the correlation between MRI radiological findings and anesthetic

considerations, challenges, and outcomes[16-18]. Understanding this correlation can enhance multidisciplinary preoperative planning, facilitate individualized anesthetic strategies, reduce perioperative complications, and improve overall surgical efficiency[19].
Therefore, the present study aims to evaluate the spectrum of MRI radiological findings in patients with orthopedic conditions and to analyze their relevance to anesthetic management. By correlating specific MRI features with anesthetic technique selection, perioperative challenges and clinical outcomes, this study seeks to highlight the importance of integrating radiological data into comprehensive anesthetic planning. Such an approach may contribute to improved patient safety, optimized resource utilization, and better interdisciplinary collaboration in orthopedic care.

OBJECTIVES

The primary objective of this study IS to evaluate the spectrum of MRI radiological findings in patients with orthopedic conditions and to determine their influence on anesthetic planning and perioperative management. The study also aimed to correlate specific MRI-detected abnormalities with the selection of anesthetic techniques, identify anesthesia-related challenges associated with various orthopedic pathologies, and assess perioperative anesthetic outcomes in relation to radiological findings.

METHODOLOGY

This prospective observational study was conducted at a tertiary care teaching hospital over a defined study period. Patients diagnosed with orthopedic conditions requiring MRI evaluation and planned surgical intervention under anesthesia were enrolled after obtaining informed consent. Adult patients of both genders with spinal, joint, traumatic, or soft-tissue orthopedic pathologies who had undergone preoperative MRI were included, while those with contraindications to MRI, unfit for anesthesia, emergency cases without prior MRI, or those refusing consent were excluded. MRI examinations were performed using standard musculoskeletal protocols and images were interpreted by experienced radiologists. Radiological findings such as bone marrow changes, joint degeneration, ligamentous and soft-tissue injuries, spinal canal stenosis, and neural compression were systematically documented.
All patients underwent comprehensive pre-anesthetic evaluation, and MRI findings were reviewed to aid anesthetic decision-making. Based on radiological severity and surgical requirements, patients received general, regional or combined anesthesia. Intraoperative parameters including duration of anesthesia, positioning difficulties, and anesthetic complications were recorded, along with postoperative recovery and pain outcomes.

Ethical considerations

The study was approved by the ethical committee from Dow university of Health sciences

STATISTICAL ANALYSIS

The collected data was analyzed using Statistical Package for Social Sciences (SPSS) version 22.Continuous variables such as age, duration of anesthesia, surgical time, and postoperative recovery time were expressed as mean ± standard deviation, while categorical variables including gender, type of orthopedic pathology, MRI findings, anesthetic technique, and perioperative complications were presented as frequencies and percentages. Comparisons between groups were performed using the independent t-test or one-way analysis of variance (ANOVA) for normally distributed variables. Associations between MRI radiological findings and anesthetic techniques were analyzed using the Chi-square test test where appropriate. Correlation between the severity of MRI findings and anesthetic or surgical complexity was assessed using Pearson or Spearman correlation coefficients. Multivariate logistic regression analysis was performed to identify independent MRI predictors of anesthetic challenges and perioperative complications. A p-value of less than 0.05 was considered statistically significant.

RESULTS

c A total of 120 orthopedic patients were included in the study. The mean age of the study population was 42.6 ± 14.3 years. Most patients belonged to ASA physical status II (45.0%), followed by ASA I (37.5%) and ASA III (17.5%), indicating a predominantly low-to-moderate anesthetic risk population (Table 1). Figure 1 illustrates the gender distribution of participants, showing a balanced representation of both sexes.

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 120)

Variable	Frequency / Value
Age (years), mean ± SD	42.6 ± 14.3
ASA Physical Status	
– ASA I	45 (37.5%)
– ASA II	54 (45.0%)
– ASA III	21 (17.5%)

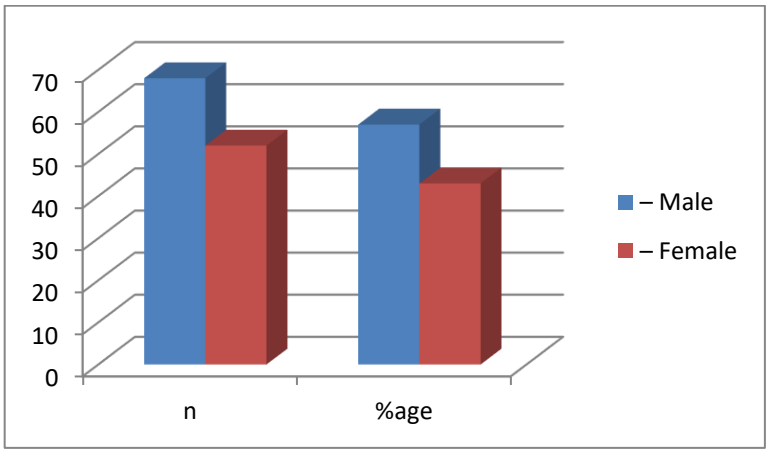


FIG 1 Showed the gender distribution of the participants

MRI evaluation revealed that degenerative changes were the most common radiological finding, observed in 28.3% of patients, followed by disc herniation or spinal stenosis (24.2%) and ligament or meniscal injuries (21.7%). Soft tissue edema or tears accounted for 15.0% of cases, while complex fractures were noted in 10.8% of patients (Table 2).

Table 2: Distribution of MRI Radiological Findings in Orthopedic Patients

MRI Radiological Finding	Number of Patients (%)
Degenerative changes	34 (28.3%)
Disc herniation / spinal stenosis	29 (24.2%)
Ligament or meniscal injury	26 (21.7%)
Soft tissue edema / tear	18 (15.0%)
Complex fractures	13 (10.8%)
Total	**120 (100%)**

Regarding anesthetic management, general anesthesia was the most frequently employed technique (48.3%), followed by regional anesthesia (35.0%) and combined anesthesia (16.7%) (Table 3). A

significant association was observed between MRI severity and the choice of anesthetic technique. Patients with mild MRI findings predominantly received regional anesthesia (57.9%), whereas those with severe MRI findings were more likely to undergo general anesthesia (68.4%). Combined anesthesia was more commonly used in patients with moderate disease severity (22.7%)

Table 3: Distribution of Anesthetic Techniques Used

Anesthetic Technique	Number of Patients (%)
General anesthesia	58 (48.3%)
Regional anesthesia	42 (35.0%)
Combined anesthesia	20 (16.7%)
Total	**120 (100%)**

MRI findings also correlated with surgical complexity. Complex fractures were associated with the longest mean surgical duration (140 ± 30 minutes) and the highest estimated blood loss (350 ± 80 ml), followed by disc herniation or spinal stenosis (110 ± 25 minutes; 250 ± 60 ml). In contrast, soft tissue injuries and ligament or meniscal injuries were associated with shorter operative times and lower blood loss (Table 5).

Table 4: Association Between MRI Severity and Anesthetic Technique

MRI Severity	General Anesthesia n(%)	Regional Anesthesia n(%)	Combined Anesthesia n (%)	Total
Mild	12 (31.6%)	22 (57.9%)	4 (10.5%)	38
Moderate	20 (45.5%)	14 (31.8%)	10 (22.7%)	44
Severe	26 (68.4%)	6 (15.8%)	6 (15.8%)	38
Total	**58**	**42**	**20**	**120**

Table 5: Correlation of MRI Findings with Surgical Complexity

MRI Finding	Mean Surgical Duration (minutes) ± SD	Estimated Blood Loss (ml) ± SD
Degenerative changes	85 ± 20	180 ± 40
Disc herniation / spinal stenosis	110 ± 25	250 ± 60
Ligament or meniscal injury	75 ± 18	150 ± 35
Soft tissue edema / tear	70 ± 15	130 ± 30
Complex fractures	140 ± 30	350 ± 80

Intraoperative anesthetic challenges varied according to MRI findings. Difficult positioning and hemodynamic instability were most frequently encountered in patients with complex fractures (76.9% and 61.5%, respectively). Failed regional blocks were also highest in this group (38.5%). Patients with disc herniation or spinal stenosis experienced higher rates of positioning difficulty (41.4%) and hemodynamic instability (31.0%) compared to other groups (Table 6)

Table 6: Intraoperative Anesthetic Challenges According to MRI Findings

MRI Finding	Difficult Positioning n (%)	Hemodynamic Instability n (%)	Failed Regional Block n (%)
Degenerative changes	8 (23.5%)	5 (14.7%)	4 (11.8%)
Disc herniation / spinal	12 (41.4%)	9 (31.0%)	8 (27.6%)

stenosis			
Ligament or meniscal injury	4 (15.4%)	3 (11.5%)	2 (7.7%)
Soft tissue edema / tear	3 (16.7%)	2 (11.1%)	1 (5.6%)
Complex fractures	10 (76.9%)	8 (61.5%)	5 (38.5%)

Postoperative outcomes differed significantly based on the anesthetic technique used. Regional anesthesia was associated with shorter recovery times (4.2 ± 1.3 hours), lower postoperative pain scores (VAS 3.6 ± 1.0), and a reduced need for ICU monitoring (7.1%) compared to general and combined anesthesia. Patients receiving general anesthesia had longer recovery times and higher pain scores, while combined anesthesia showed the highest proportion of ICU admissions (25.0%) (Table 7).

Table 7: Postoperative Outcomes in Relation to Anesthetic Technique

Outcome	General Anesthesia	Regional Anesthesia	Combined Anesthesia
Mean recovery time (hours) ± SD	6.5 ± 1.8	4.2 ± 1.3	5.0 ± 1.5
Postoperative pain score (VAS)	5.8 ± 1.2	3.6 ± 1.0	3.9 ± 1.1
Need for ICU monitoring n (%)	12 (20.7%)	3 (7.1%)	5 (25.0%)

Multivariate analysis identified severe degenerative changes, spinal canal stenosis, and complex fractures as significant independent predictors of increased anesthetic complexity. Complex fractures demonstrated the strongest association (OR = 4.2, $p < 0.001$), followed by spinal canal stenosis (OR = 3.1, $p = 0.001$) and severe degenerative changes (OR = 2.4, $p = 0.004$). Soft tissue injuries were not found to be a significant predictor of anesthetic complexity.

Table 8: Multivariate Analysis of MRI Predictors of Anesthetic Complexity

MRI Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Severe degenerative changes	2.4	1.3–4.6	0.004
Spinal canal stenosis	3.1	1.6–6.0	0.001
Complex fractures	4.2	2.0–8.8	<0.001
Soft tissue injury	1.2	0.6–2.3	0.410

DISCUSSION

The present study demonstrated that the critical role of magnetic resonance imaging (MRI) in the evaluation and management of orthopedic conditions, extending beyond diagnostic precision to influence anesthetic planning and perioperative decision-making[19]. The superior soft-tissue contrast and multiplanar capability of MRI allow for detailed visualization of ligaments, cartilage, nerve roots and spinal structures, often detecting abnormalities that may not be apparent on conventional radiographs or CT scans. This advanced imaging is essential for accurate preoperative assessment and tailoring anesthetic techniques appropriately.

A systematic review on spinal cord injury demonstrated that MRI findings such as cord compression, disc herniation and ligamentous injury frequently alter clinical management and surgical strategy, reinforcing MRI's value in decision-making prior to intervention[20-21]. In the context of orthopedic surgery, these detailed radiological insights influence anesthetic choices, such as determining whether regional anesthesia is feasible or if general anesthesia with advanced airway planning is more appropriate due to spinal abnormalities[22].

MRI also plays a crucial role in evaluating soft-tissue lesions associated with fractures. MRI can identify concomitant meniscal, ligamentous and cartilage injuries that are poorly visualized on X-rays or CT, thereby guiding both surgical and anesthetic planning. This depth of anatomical information allows anesthesiologists to anticipate challenges such as prolonged surgical time or heightened pain responses, enabling pre-emptive analgesic planning and patient counseling[23].

However, the reliability and clinical utility of MRI are not entirely without limitations. A survey of orthopedic surgeons revealed concerns regarding MRI accuracy, particularly in patients with prior hardware or surgeries. In these settings, MRI may produce inconclusive results, prompting the need for careful interpretation and, at times, supplementary imaging or intraoperative evaluation[24,25]. These limitations underscore the importance of correlating MRI findings with clinical examination and other imaging modalities to optimize preoperative planning.

From an anesthetic perspective, pre-surgical imaging enhances perioperative safety by facilitating risk stratification and planning. A recent review underscored that pre-surgical imaging such as MRI allows anesthesiologists to anticipate airway difficulties, detect spinal deformities that might complicate regional blocks, and identify comorbid conditions influencing anesthetic technique selection[26]. For instance, patients with significant spinal stenosis or deformity on MRI may be less suitable candidates for neuraxial anesthesia and may require advanced airway management strategies under general anesthesia.

The practical implications of MRI findings extend to regional anesthesia techniques as well. Imaging can assist in confirming the location and severity of pathology amenable to peripheral nerve blocks while highlighting anatomical variations or distortions that might impact block efficacy. This targeted approach not only enhances pain control but also reduces the likelihood of block failure or complications.

Moreover, specialized circumstances such as pediatric imaging often require anesthesia or deep sedation to ensure immobility and high-quality imaging. Studies in pediatric populations with skeletal dysplasias indicate that tailored sedation protocols can achieve excellent imaging quality with minimal complications, emphasizing the need for anesthetic expertise during MRI acquisition itself.

Despite debates around the overuse or inappropriate ordering of MRI scans in certain orthopedic referrals, which may not always change clinical management, the overall evidence supports MRI's indispensable role when used judiciously. Integrating MRI into preoperative workflows, especially for complex or high-risk cases, enhances interdisciplinary collaboration among radiologists, orthopedic surgeons, and anesthesiologists, ultimately improving patient outcomes.

In summary, our findings and existing literature converge on the understanding that MRI significantly contributes to comprehensive orthopedic assessment and anesthetic planning. While limitations such as variability in image interpretation and cost considerations remain, the effective use of MRI informs surgical strategy, guides anesthetic management and facilitates better perioperative care. Future research should aim to refine standardized protocols for integrating MRI findings into anesthetic risk stratification models and explore cost-effectiveness in diverse clinical settings.

CONCLUSION

The study demonstrated that MRI radiological findings play a significant role in preoperative assessment and anesthetic planning for orthopedic patients. Specific MRI-detected abnormalities, including advanced degenerative changes, spinal canal stenosis, extensive soft-tissue involvement, and complex traumatic lesions, were found to be associated with increased anesthetic complexity, selection of anesthesia technique, and perioperative challenges. Incorporation of detailed MRI evaluation into anesthetic decision-making facilitates individualized anesthetic strategies, enhances patient safety, and improves perioperative outcomes. These findings underscore the importance of a multidisciplinary approach involving radiologists, orthopedic surgeons, and anesthesiologists to optimize surgical care. Further large-scale, multicenter studies are recommended to strengthen

evidence and establish standardized protocols integrating MRI findings into anesthetic management in orthopedic practice.

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