Journal of Advances in Medicine and Medical Research

Volume 36, Issue 5, Page 73-81, 2024; Article no.JAMMR.114787
ISSN: 2456-8899, NLM ID: 101711724
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Association between Facet Fluid on Supine Axial T2-Weighted MRI and Sagittal Instability on Dynamic Standing Lateral Radiographs in Patients with Degenerative Lumbar Disease

Sadaf Nasir [a++], Manzar Hussain [b++], Bushra Shamim [a++], Fawwaz Bin Shahab [b#] and Muhammad Yassar Jazaib Ali [b†*]

[a] Department of Radiology, Liaquat National Hospital and Medical College, Karachi, Pakistan.
[b] Department of Neurosurgery, Liaquat National Hospital and Medical College, Karachi, Pakistan.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2024/v36i55416

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114787

Original Research Article

Received: 14/01/2024
Accepted: 23/03/2024
Published: 03/04/2024

ABSTRACT

Study Design: Prospective observational study conducted at a large tertiary care center in Karachi, Pakistan.

[++] Associate Professor;
[#] Postgraduate Resident;
[†] Senior Registrar;
**Corresponding author: E-mail: yasirkhebar@yahoo.com;*

Purpose: To examine the association between positive facet fluid on T2-weighted MRI of lumbosacral spine and the presence of instability on lateral flexion/extension radiographs, and to determine whether a correlation exists between the quantity of facet fluid on axial MRI and the degree of spinal instability on lateral standing flexion/extension radiographs.
Overview of literature: The presence of increased facet fluid on axial T2-weighted magnetic resonance imaging (MRI) has been proposed as a potential marker for motion segment instability in the lumbar spine. Both facet fluid on MRI and spinal instability on dynamic x-rays are crucial in diagnosing and managing low back pain, guiding decisions on surgical interventions.
Methods: We analyzed the prospectively collected data from patients meeting the inclusion criteria. Facet fluid measurements were made according to Schinnerer's criteria on axial T2-weighted images and anterior translation as a marker of instability was evaluated on dynamic radiographs for all eligible patients. Statistical analysis was performed using IBM SPSS version 23, employing cross-tabulations, chi-square tests, and Pearson correlation. The study utilized a null hypothesis to evaluate the association between facet fluid and spinal instability.
Results: Our findings demonstrated a statistically significant association between positive facet fluid on MRI and the occurrence of instability on lateral flexion/extension radiographs. Moreover, we found a strong positive correlation between the volume of facet fluid on axial MRI and the level of spinal instability on standing flexion/extension radiographs.
Conclusion: Based upon these outcomes, we propose that standing lateral flexion–extension radiographs should be routinely administered to patients exhibiting increased facet fluid signals on MRI, as they may provide valuable information regarding potential spinal instability. Further research will help establish the clinical utility of this approach in managing degenerative lumbar diseases.

Keywords: Lumbar facet fluid; axial T2-weighted MRI; motion segment instability; degenerative lumbar disease; dynamic standing lateral radiography.

1. INTRODUCTION

Mechanical back pain caused by segmental spinal instability is a common clinical condition. Spinal instability refers to abnormal movement between two or more vertebrae in the spine, which can result from various conditions such as trauma, degenerative changes, and after lumbar spinal surgery [1]. Several radiological parameters, including static and dynamic lumbosacral spine x-rays, MRI, 3-D computed tomography, and provocative discography, are suggested for detecting motion segment instability [2-7].

Traditionally, instability of the lumbosacral spine was diagnosed with flexion/extension x-rays. However, as MRI is usually the initial investigation for patients with back pain, evaluation of facet fluid can provide a clue to spinal instability. Facet joints, located between the superior and inferior articular facets of the two vertebral bodies, help stabilize the spine and allow for movement [8]. Signal changes on MRI in the facet joint can be seen in a spectrum of inflammatory or degenerative joint diseases, including osteoarthritis, facet joint syndrome, and spinal stenosis [9].

When a patient with this condition lies supine during an MRI examination, the unstable lumbar spinal segment is unloaded and can reduce posteriorly, producing a gap within the degenerated facet joint. Fluid that accumulates in this gap can be detected as a hyperintense signal on T2-weighted MRI sequences [10,11]. However, even asymptomatic individuals may have these findings, and it is unclear whether increased facet fluid is a reliable marker of motion segment instability [3,12-15].

Facet fluid on MRI and spinal instability on dynamic lumbosacral x-rays are two important interrelated findings in the evaluation of low back pain, providing valuable information for the diagnosis and management, such as the need for simple decompression versus arthrodesis [16,17]. Therefore, we conducted this study to analyze the association between increased lumbar facet fluid detected on supine MRI and sagittal instability detected on dynamic radiographs in patients with degenerative lumbar disease.

The null hypotheses for this study were that, there is no association between increased facet fluid on axial images of supine MRI and sagittal instability detected on standing lateral

flexion/extension radiographs in patients with degenerative lumbar disease, and that there is no correlation between the amount of facet fluid on MRI and the grade of spondylolisthesis on flexion/extension radiographs.

2. MATERIALS AND METHODS

Study Design: Prospective observational study conducted at one of the largest tertiary care centre in Karachi, Pakistan from January 2020 to June 2021, with prospective data collection.

The study included adult patients who underwent lumbar spine MRI with signs and symptoms of back pain, with or without lumbar radiculopathy, and had degenerative spinal disease on MRI of the lumbosacral spine. Patients with spinal fractures, spinal infection, spinal tumor, deformity, or skeletal dysplasia and those who have previously underwent spinal surgery were excluded. All patients meeting the inclusion criteria underwent dynamic flexion/extension radiographs.

The facet fluid was measured on axial T2-weighted images using Schinnerer criteria [18]. with joint effusion greater than 1mm considered as increased fluid. All MRI scans were performed on 3T Toshiba Atlas Excel ART Vantage MRI machine. A qualified radiologist with fellowship degree and at least five years of post-fellowship experience in neuroradiology interpreted the images.

The presence or absence of segmental instability was assessed on the weight-bearing (standing) flexion/extension views of lumbar radiographs of the same patients. Instability was defined on weight-bearing flexion/extension views as anterior translation of the superior vertebra over the inferior (measured in millimeters) on lateral flexion/extension radiographs.

IBM SPSS version 23 was used for statistical analysis. Cross-tabulations and chi-square tests were used to analyze the statistically significant association between positive and negative facet fluid on MRI and the presence or absence of instability on radiographs, with p-value of <0.05 considered significant. Pearson correlation was used to analyze the correlation between the amount of facet fluid on MRI and the grade of spinal instability on radiographs. Age was presented as mean ± S.D, and frequencies were shown on histogram.

We used the null hypothesis to accept or reject our hypothesis that there exists an association between increased facet fluid detected on axial T2-weighted images and dynamic weight-bearing flexion/extension views and there is correlation between the amount of facet fluid on MRI and the grade of spondylolisthesis on flexion/extension radiographs.

3. RESULTS

In our research, a total of 216 participants took part, consisting of 91 males and 125 females. The average age was 58.99 years (standard deviation = 10.28), ranging from 33 to 84 years. Fig. 1 illustrates the distribution of age frequencies.

Examinations of MRI lumbar spine revealed exaggerated facet fluid (>1mm) in 93 patients, categorized as positive, while 123 patients were classified as negative. Among the 93 patients with increased facet fluid on MRI axial T2-weighted images, only 14 showed instability on supine sagittal MRI of the lumbar spine. However, on flexion/extension views of the same patients, 58 exhibited signs of spinal instability.

Table 1. Cross tabulation between instability as observed on flexion / extension radiographs in standing position and amount of facet fluid detected on axial MRI demonstrating a significant association between positive facet fluid on MRI and the presence of instability on radiographs

		Facet fluid on axial MRI positive >1mm =1, negative < 1mm =2		Total
		1.00	2.00	
Instability on flexion extension radiographgs	1.00	58	12	70
PRESENT=1, NOT PRSENT=2	2.00	35	111	146
Total		93	123	216

Table 2. Chi Square tests on the data obtained between flexion / extension radiographs in standing position and amount of facet fluid detected on axial MRI

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	66.914[a]	1	.000		
Continuity Correction[b]	64.534	1	.000		
Likelihood Ratio	70.296	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	66.605	1	.000		
N of Valid Cases	216				

a.0 cells (0.0%) have expected count less than 5. The minimum expected count is 30.14. b. Computed only for a 2x2 table

Table 3. Pearson correlations demonstrating a strong positive correlation between the amount of facet fluid on axial MRI and the grade of spinal instability on standing flexion/extension radiographs

		Value of facet fluid	Grade of spinal instability
Value of facet fluid	Pearson Correlation	1	.923[a]
	Sig. (2-tailed)		.000
	N	216	216
Grade of spinal instability	Pearson Correlation	.923[a]	1
	Sig. (2-tailed)	.000	
	N	216	216

a. Correlation is significant at the 0.01 level (2-tailed)

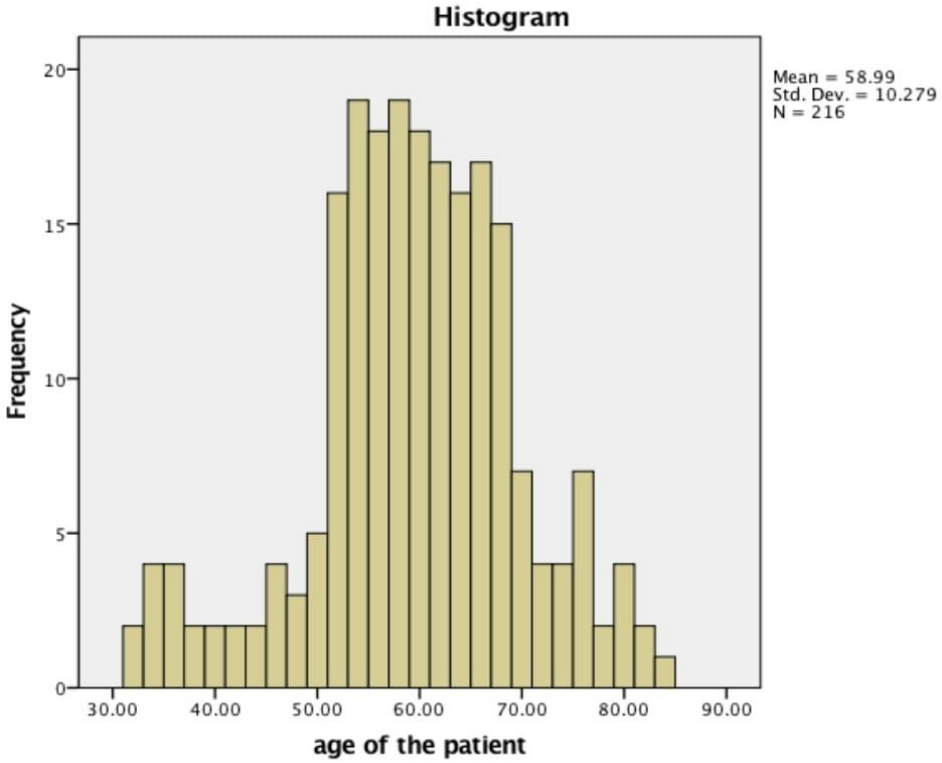

Fig. 1. The distribution of data with respect to age frequencies comprising of total 216 patients

Conversely, among the 123 patients without increased facet fluid on MRI axial T2-weighted images, none displayed instability on supine sagittal MRI of the lumbar spine. On flexion/extension views of these patients, 12 tested positive for spinal instability.

Cross-tabulation statistics revealed a significant association between positive facet fluid on MRI and the presence of instability on radiographs, leading to the rejection of null hypothesis no. 1 (see Table 1 and Table 2). Additionally, Pearson correlation analysis showed a strong positive correlation between the amount of facet fluid on axial MRI and the grade of spinal instability on standing flexion/extension radiographs. As a result, null hypothesis no. 2 was rejected (see Table 3). Based upon these outcomes, we propose that standing lateral flexion–extension radiographs should be routinely administered to patients exhibiting increased facet fluid signals on MRI, as they may provide valuable information regarding potential spinal instability. Further research will help establish the clinical utility of this approach in managing degenerative lumbar diseases.

4. DISCUSSION

Back pain is a prevalent clinical condition often attributed to segmental motion instability. Factors such as intervertebral disc degeneration and lumbar facet joint degeneration are known contributors to spinal instability, which can develop over time [19]. The lumbar spinal segment functions as a cohesive unit where the intervertebral disc and facet joints work together to provide stability and withstand spinal stresses.

In a biomechanical study by Adams and Hutton,[20] the lumbar facet joints were identified as crucial in limiting motion between vertebrae and safeguarding intervertebral discs from excessive forces during flexion, rotation, and shear. Axial T2-weighted images have been utilized to detect segmental motion instability, although it is recognized that dynamic slip may be reduced in the supine position, potentially masking spondylolisthesis during supine MRI.

Kirkaldy-Willis outlines three-phase model for degeneration [21]. The initial phase involves dysfunction in discoligamentous structures with minimal anatomical alterations. The subsequent phase is characterized by relative instability, marked by reduced disc height, laxity in facet capsules and ligaments, and articular changes, potentially resulting in excessive translational and rotational movement. Further degeneration in this stage leads to increased rigidity and stabilization through osteophyte formation and fibrosis. Theoretically, as degeneration progresses from instability to restabilization, there should be a decline in facet joint effusion [21].

Increased facet fluid on axial T2-weighted images has been proposed as a potential marker of instability, suggesting its utility in recommending spinal arthrodesis [16]. Researchers have explored the use of static MRI for detecting spinal instability. Studies by Mailleux et al. [22], Rihn et al. [12], Chaput et al. [23], Schinnerer et al. [18], Cho et al. [24] and others [25,26] have highlighted the association between facet fluid on MRI and spinal instability, particularly in cases of degenerative spondylolisthesis. The study by Rihn et al. [12] identified close linear relationship between the presence of facet fluid and the degree of instability, highlighting the potential utility of MRI findings as indicators of lumbar instability. The findings also revealed that the presence of facet fluid on MRI serves as a reliable predictor of radiographic lumbar instability, boasting relatively high positive (82%) and negative (83%) predictive values.

We utilized criteria by Shinnerer et al. [18] to document presence of abnormal fluid signals within the facet joins. The Shinnerer criteria [25] for measuring facet fluid involved detailed assessment of axial MRI images, focusing specifically on the presence of increased fluid within the facet joints. Each facet joint (left and right sides separately) was examined independently. Joint was considered normal if the amount of fluid present was no more than what was deemed physiologic, defined as a fluid signal measuring less than 1 millimeter between the articular processes when measured as a straight line perpendicular to the joint line. If the observed fluid exceeded this threshold of 1 millimeter, it was classified as abnormal or "exaggerated." (Fig. 2) The presence or absence of segmental instability was assessed on the weight-bearing (standing) flexion/extension views of lumbar radiographs of the same patients. Instability was defined on weight-bearing flexion/extension views as anterior translation of the superior vertebra over the inferior on lateral flexion/extension radiographs. Anterolisthesis was quantified in

millimeters at every vertebral level spanning from L1-2 to L5-S1. The measurement of anterolisthesis was conducted from the posterior inferior corner of the superior vertebra to the posterior superior corner of the inferior vertebra. (Fig. 3)

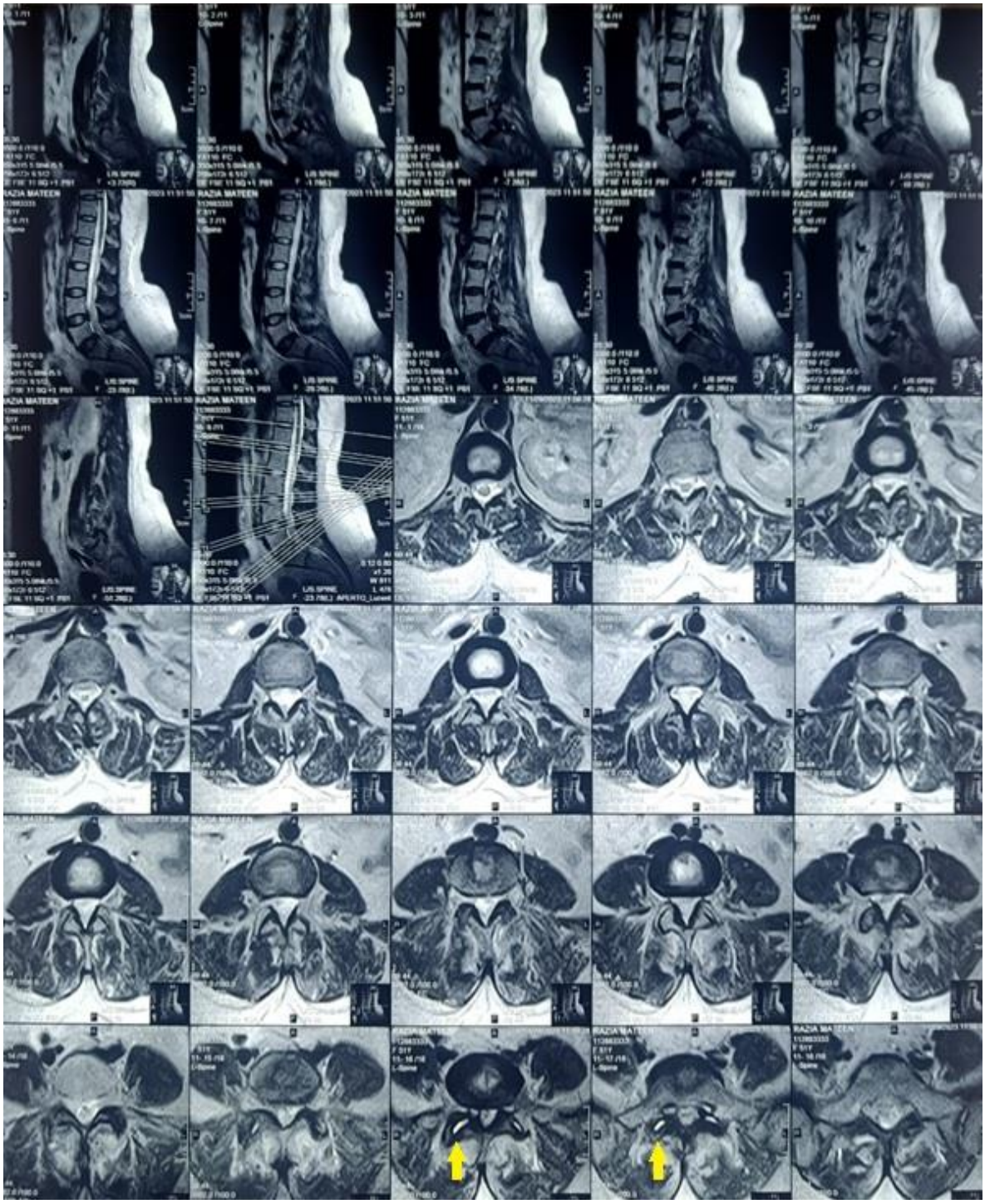

Fig. 2. MRI Lumbosacral Spine T2- weighted image of the patient showing presence of significant fluid in facet joints at L5-S1 level on axial cuts with abnormal facet fluid marked with yellow arrows but no abnormality in alignment at L5-S1 level on supine sagittal view of MRI

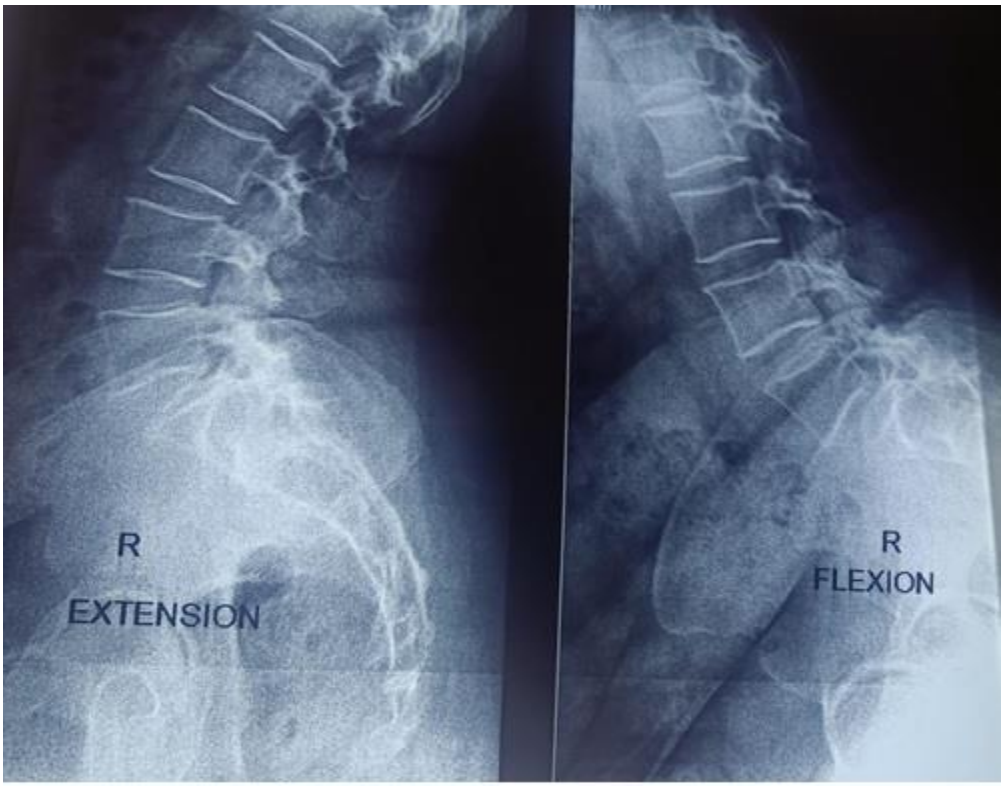

Fig. 3. X-Ray Flexion Extension of the same patient showing significant anterolisthesis of L5 over S1 vertebra

Our study revealed a significant association between lumbar facet fluid detected on axial MRI and radiographic instability observed on standing flexion/extension lumbar radiographs in patients with degenerative lumbar disease. We also found a strong positive correlation between the amount of facet fluid on axial T2-weighted MRI and the grade of spinal instability on lateral flexion/extension radiographs in standing position.

Strengths of our study include its prospective design and stringent inclusion criteria. Limitations include the lack of randomization and relatively small sample size. Pending further data, we recommend conducting standing lateral flexion–extension radiographs for all patients showing increased facet fluid signal on MRI. A prospective randomized trial could provide more conclusive evidence, although conducting MRI on asymptomatic individuals poses challenges.

5. CONCLUSION

In conclusion, our study underscores significant relationship between lumbar facet fluid identified on axial MRI and radiographic instability observed on standing flexion/extension lumbar radiographs among patients with degenerative lumbar disease. Furthermore, we observed a positive correlation between the quantity of facet fluid on axial T2-weighted MRI and the degree of spinal instability on lateral flexion/extension radiographs in a standing position. Strengths of our investigation include its prospective nature and rigorous inclusion criteria, which enhance the validity of our findings. However, limitations such as the absence of randomization and a relatively small sample size underscore the need for further research. We advocate for the routine use of standing lateral flexion–extension radiographs in patients exhibiting elevated facet fluid signal on MRI, as they may provide valuable information regarding potential spinal instability. Further research will help establish the clinical utility of this approach in managing degenerative lumbar diseases.

CONSENT AND ETHICAL APPROVAL

All adult participants provided written informed consent before undergoing lumbar spine MRI and dynamic flexion/extension radiographs. The study adhered to the Declaration of Helsinki

principles, and patient confidentiality was strictly maintained. Proper approval was taken from the hospital's ethical review committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hauser RA, Matias D, Woznica D, Rawlings B, Woldin BA. Lumbar instability as an etiology of low back pain and its treatment by prolotherapy: A review. Journal of Back and Musculoskeletal Rehabilitation. 2022;35:701-12.
2. Vitzthum H-E, König A, Seifert V. Dynamic examination of the lumbar spine by using vertical, open magnetic resonance imaging. Journal of Neurosurgery: Spine. 2000;93:58-64.
3. Haughton VM, Rogers B, Meyerand ME, Resnick DK. Measuring the axial rotation of lumbar vertebrae *in vivo* with MR imaging. American Journal of Neuroradiology. 2002;23:1110-6.
4. Ochia RS, Inoue N, Renner SM, et al. Three-dimensional *in vivo* measurement of lumbar spine segmental motion. Spine. 2006;31:2073-8.
5. Jinkins JR, Dworkin J. Proceedings of the state-of-the-art symposium on diagnostic and interventional radiology of the Spine, Antwerp, September 7, 2002 (Part two). Upright, weight-bearing, dynamic-kinetic MRI of the spine: pMRI/kMRI. JBR-BTR: Organe de la Societe Royale Belge de Radiologie (SRBR)= Orgaan van de Koninklijke Belgische Vereniging Voor Radiologie (KBVR). 2003;86:286-93.
6. Wang Y, Huang K. Research progress of diagnosing methodology for lumbar segmental instability: A narrative review. Medicine. 2022;101:e28534.
7. Zhou Q-s, Sun X, Chen X, et al. Utility of natural sitting lateral radiograph in the diagnosis of segmental instability for patients with degenerative lumbar spondylolisthesis. Clinical Orthopaedics and Related Research®. 2021;479:817-25.
8. Singh K, Hislop T, Lahiri A, Tekke P. Lumbar facet joint fluid: A reliable sign of lumbar instability. Cureus. 2023;15: e39332.
9. Perolat R, Kastler A, Nicot B, et al. Facet joint syndrome: From diagnosis to interventional management. Insights into Imaging. 2018;9:773-89.
10. Iwata S, Eguchi Y, Takaoka H, et al. MRI T2-mapping of lumbar facet joints is effective for quantitative evaluation of lumbar instability in patients with degenerative lumbar disorders. European Spine Journal. 2022;31:1479-86.
11. Naeem K, Nathani KR, Barakzai MD, et al. Modifications in lumbar facet joint are associated with spondylolisthesis in the degenerative spine diseases: A comparative analysis. Acta Neurochirurgica. 2021;163:863-71.
12. Rihn JA, Lee JY, Khan M, et al. Does lumbar facet fluid detected on magnetic resonance imaging correlate with radiographic instability in patients with degenerative lumbar disease? Spine. 2007;32:1555-60.
13. Bridwell KH, Sedgewick TA, O'Brien MF, Lenke LG, Baldus C. The role of fusion and instrumentation in the treatment of degenerative spondylolisthesis with spinal stenosis. Clinical Spine Surgery. 1993;6: 461-72.
14. Herkowitz HN, Kurz L. Degenerative lumbar spondylolisthesis with spinal stenosis. A prospective study comparing decompression with decompression and intertransverse process arthrodesis. JBJS. 1991;73:802-8.
15. Mardjetko S, Connolly P, Shott S. Degenerative lumbar spondylolisthesis: A meta-analysis of literature 1970–1993. Spine. 1994;19:2256S-65S.
16. Ben-Galim P, Reitman CA. The distended facet sign: An indicator of position-dependent spinal stenosis and degenerative spondylolisthesis. The Spine Journal. 2007;7:245-8.
17. Blumenthal C, Curran J, Benzel EC, et al. Radiographic predictors of delayed instability following decompression without fusion for degenerative grade I lumbar spondylolisthesis. Journal of neurosurgery. Spine. 2013;18:340-6.
18. Schinnerer KA, Katz LD, Grauer JN. MR findings of exaggerated fluid in facet joints predicts instability. Clinical Spine Surgery. 2008;21:468-72.
19. Jang SY, Kong MH, Hymanson HJ, Jin TK, Song KY, Wang JC. Radiographic parameters of segmental instability in lumbar spine using kinetic MRI. Journal of Korean Neurosurgical Society. 2009;45:24.

20. Adams MA, Hutton WC. The mechanical function of the lumbar apophyseal joints. Spine. 1983;8:327-30.
21. Kirkaldy-Willis W. Presidential symposium on instability of the lumbar spine: Introduction. Spine. 1985;10:254.
22. Mailleux P, Ghosez J, Bosschaert P, Malbecq S, Coulier B. Distension of the inter-facet joints in MRI: and indirect sign of an existing underestimation of spondylolisthesis and canal stenosis. Journal Belge de Radiologie. 1998;81:283-5.
23. Chaput C, Padon D, Rush J, Lenehan E, Rahm M. The significance of increased fluid signal on magnetic resonance imaging in lumbar facets in relationship to degenerative spondylolisthesis. Spine. 2007;32:1883-7.
24. Cho BY, Murovic JA, Park J. Imaging correlation of the degree of degenerative L4–5 spondylolisthesis with the corresponding amount of facet fluid. Journal of Neurosurgery: Spine. 2009;11: 614-9.
25. Oishi Y, Murase M, Hayashi Y, Ogawa T, Hamawaki J-i. Smaller facet effusion in association with restabilization at the time of operation in Japanese patients with lumbar degenerative spondylolisthesis. Journal of Neurosurgery: Spine. 2010;12: 88-95.
26. Lattig F, Fekete TF, Grob D, Kleinstück FS, Jeszenszky D, Mannion AF. Lumbar facet joint effusion in MRI: A sign of instability in degenerative spondylolisthesis? European Spine Journal. 2012;21:276-81.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/114787