

MRI Finding of Cartilaginous Endplates Herniation of Lumbar Spine in Patient with Low Back Pain

Mohammed Abd Kadhim*, Mansour Eidan Dawood Al – Zubaidi**,
Firas Mahmood Yaqub**

ABSTRACT:

BACKGROUND:

Magnetic resonance imaging (MRI) provides a noninvasive assessment of the lumbar spine. Little is thought about the MRI characteristics of cartilaginous endplate (CEP) and CEP herniation on the ground that their normal thickness is only 0.6mm, making it hard to perceive at routine MRI examinations

OBJECTIVE :

To study the reliable magnetic resonance imaging findings suggested cartilage endplate herniation in lumbar spine.

PATIENTS AND METHODS:

This prospective study was conducted on 46 patients with low back pain in the MRI unit of Al-Imamein Alkadhmein Medical City, Baghdad, Iraq between September, 2016 and August 2017. Inclusion criteria: adult patients with lumbar disc herniation proved by MRI with surgical prove of cartilage end plates herniation. Exclusion criteria include: patients with previous back surgery, history of spinal tumor and the general contraindications to MRI. Sagittal and axial T1-weighted spino-echo image and sagittal and axial T2 weighted spine echo images were obtained. Statistical analysis using SPSS version 23, the level of significance (p value) was set as ≤ 0.05 .

RESULT:

Forty six patients with low back pain were included in this study, the mean age of 44 ± 9 years, 26 patients were females and 20 patients were males. The CEP herniation was detected by MRI among 52.2% of patients with back pain. There was a highly significant association between CEP and increased age of the patients, back pain radiated to both limbs, L4-5 defect site, modic changes and lumbar posterior marginal nodes (p value 0.01, 0.004, 0.02, 0.03 and <0.001 respectively). No significant differences between patients with CEP herniation and those without CEP herniation regarding posterior osteophytes, dorsal vertebral cornal defect, heterogeneous signal intensity and posterior corner and mid endplate irregularities. There was a highly significant association between lumbar posterior marginal nodes and CEP herniation ($p < 0.001$).

CONCLUSION:

CEP herniation is more prevalent among advanced age and at lower lumbar level. The most common MRI signs related to CEP herniation were modic changes in mid endplate and lumbar posterior marginal nodes.

KEY WORDS: MRI, cartilaginous endplates herniation, lumbar spine, low back pain.

INTRODUCTION:

The structural integrity of the cartilaginous endplate (CEP) is basic to intervertebral disc health, proper endplate integrity is essential for

resisting certain disc herniation and tears keeping up a uniform intradiscal stress distribution and regulating the transport of disc nutrients and metabolites ^(1,2). Significantly, failure of the endplate to perform these functions is theorized to quicken disc degeneration ⁽³⁾. Endplate integrity is also critical for vertebral bone health; endplate cartilage damage significantly associates with innervated bone marrow lesions ⁽⁴⁾ which are suspected to be the pain generator in 30–40% of patients with chronic low

*Professor in Medical Collage/ Al-Nahrain University.

Consultant radiologist in Al-Imamian Al-Kadhmyian Medical City/ Baghdad Iraq.

**Radiologist in Al-Imamian Al-Kadhmyian Medical City/ Baghdad Iraq.

back pain ⁽⁵⁾. Consequently, elucidating the factors that influence endplate cartilage integrity is fundamental to understanding the reason of disc degeneration and chronic low back pain and could help build up new focuses for diagnosis and treatment ⁽⁶⁾.

An intervertebral disc has three major structural components: nucleus pulposus, annulus fibrosus, and CEP. Many reports have showed up on the anatomy, mechanics, and chemistry of the nucleus and annulus, yet little is thought about the MRI characteristics of CEP and CEP herniation on the ground that their normal thickness is only 0.6mm, making it hard to perceive at routine MRI examinations ⁽⁷⁾. CEP comprises of a thin layer of hyaline cartilage between a disc and a vertebral body. Functionally, CEP is considered an entryway for supplement transport from blood vessels into its central disc. It is the most important factor in controlling dispersion of the disc proper as it is the only source of nourishment to the nucleus pulposus ⁽⁸⁾. Endplate damage, which can begin as site-specific focal breaks, can result in a cascade of events resulting in degeneration. In such a case, CEP becomes sclerotic and loses contact with blood vessels, giving less nutrition to the disc and the CEP itself. Accordingly, the proteoglycan content reduces inside the disc; the outcome is loss of water and osmotic pressure in the disc ⁽⁹⁾.

Magnetic resonance imaging (MRI) provides a noninvasive accurate morphologic assessment of the lumbar spine and permits an evaluation of the relationship between morphologic findings and disc herniation ⁽¹⁰⁾.

AIM OF THE STUDY:

To study the reliable magnetic resonance imaging findings suggested cartilage endplate herniation in lumbar spine in patients with low back pain.

PATIENT AND METHODS:

Study design setting: this prospective study was conducted in Magnetic Resonance Imaging (MRI) unit of Radiology Department at Al-Imamein Alkadhmein Medical City, Baghdad, Iraq through the period from 1st of September, 2016 to 1st of August 2017.

Study population: 46 patients presented to MRI unit with lower back pain and planned for spine surgery for treatment of disc herniation.

Inclusion criteria: Adult patients with lumbar disc herniation proved by MRI with surgical

prove of cartilage end plates herniation after performing lumbar spine surgery. **Exclusion**

criteria include: patients with previous back surgery, patients with history of spinal tumor and the general contraindications to MRI. **Ethical considerations:** approval was taken from Institutional Review Board/Al-Nahrain College of Medicine. Oral informed consent was taken from the patients before participation in the study.

All the patients included in the study had long history of lower back pain and referred from orthopedics and/or rheumatology departments or planned for spine surgery and referred for pre-operative evaluation. Full history and examines were done for all the patients and the information were reported in a questionnaire. MRI of the lumbar spine was conducted; the MRI machine used was Magnetom Avanto (SIMENS medical system, Germany). The examination was done in the supine position with cushion under both knees. Sagittal and axial T1-weighted spino-echo image (TR/TE, 817/9.9) and sagittal and axial T2 weighted spine echo images (TR/TE, 3500/99) were obtained. The slice thickness of T1 and T2 was 4mm. The interpretation was done by 2 radiologists. The following findings were noted and recorded: posterior marginal nodes, posterior osteophytes, mid endplate irregularities, heterogeneous low signal intensity of extruded material and modic changes in posterior corners and mid endplate. The patients underwent surgery and followed up to determined whether there is endplate herniation and correlating the MRI and surgical results with the histopathological findings .

Statistical analysis: the data were analyzed by the application of Microsoft excel program and Statistical Package for Social Sciences (SPSS) version 23. Outcomes of analysis were arranged in scales variables (means and standard deviation) and in categorical variables. Chi square test was used to compare between categorized variables and Fishers' exact test was used for comparison between categorical data when expected variables was less than 20% of total. The level of significance (p value) was set as ≤ 0.05 .

RESULTS:

Forty six patients with low back pain were included in this study, mean age of 44 ± 9 years, 26 patients were females and 20 patients were males with female to male ratio as 1.3:1. Cartilaginous endplate herniation was detected by MRI among 52.2% of patients.

MRI ENDPLATES HERNIATION OF LUMBAR SPINE

There was a highly significant association between increased age of the patients with back pain and CEP herniation ($p=0.01$). No significant differences between patients with CEP herniation and those without CEP herniation regarding their gender. There was a significant association

between patients with CEP herniation and back pain radiated to both limbs ($p=0.004$). A significant association was observed between L4-5 defect site and CEP herniation detected by MRI ($p=0.02$), all these findings were shown in table 1.

Table 1: Distribution of patients' sociodemographic characteristics, patients' chief complaints and defect sites according to CEP herniation.

Variable	No CEP		CEP		χ^2	P
	No.	%	No.	%		
Age					18.2*	<0.001 Highly significant
<40 years	13	59.1	1	4.2		
40-49 years	7	31.8	11	45.8		
≥50 years	2	9.1	12	50.0		
Gender					0.06	0.8 Not significant
Male	10	45.5	10	41.7		
Female	12	54.5	14	58.3		
Chief complaint						
Back pain	0	-	4	16.7	13.1*	0.004 Significant
Back pain radiated to	1	4.5	7	29.2		
Back pain radiated to	14	63.6	12	50.0		
Back pain radiated to	7	31.8	1	4.2		
Site						
L4-L5	8	36.4	18	75.0	7.3*	0.02 Significant
L5-S1	13	59.1	6	25.0		
L3-L4	1	4.5	0	-		

No significant differences between patients with CEP herniation and those without CEP herniation regarding posterior osteophytes, dorsal vertebral cornal defect, heterogeneous signal intensity and posterior corner and mid endplate irregularities. A significant association was observed between modic changes in mid endplate and CEP herniation ($p=0.03$). There was a highly

significant association between lumbar posterior marginal nodes and CEP herniation ($p<0.001$). The presence of all these findings in MRI (posterior osteophytes, dorsal vertebral cornal defect, heterogeneous signal intensity, posterior corner and mid endplate irregularities, modic changes in mid endplate, lumbar posterior marginal nodes) can be ascertain of CEP herniation, all these were shown in table 2.

Table 2: Distribution of MRI findings according to CEP herniation.

MRI findings	No CEP		CEP		χ^2	P
	No.	%	No.	%		
Posterior osteophytes					3.4	0.06 Not significant
Positive	6	27.3	13	54.2		
Negative	16	72.7	11	45.8		
Dorsal vertebral cornal defect					0.4	0.8 Not significant
Positive	14	63.6	16	66.7		
Negative	8	36.4	8	33.3		
Modic changes in mid endplate					4.3	0.03 Significant
Positive	11	50.0	19	79.2		
Negative	11	50.0	5	20.8		
Heterogeneous signal intensity of extruded disc					0.7	0.3 Not significant
Positive	4	18.2	7	29.2		
Negative	18	81.8	17	70.8		
Modic changes in posterior corner					0.8	0.4 Not significant
Positive	9	40.9	13	54.2		
Negative	13	59.1	11	45.8		
Mid endplate irregularities					0.1	0.7 Not significant
Positive	9	40.9	11	45.8		
Negative	13	59.1	13	54.2		
Lumbar posterior marginal nodes					15.9	<0.001 Highly significant
Positive	2	9.1	16	66.7		
Negative	20	90.9	8	33.3		

DISCUSSION:

Vertebral endplate is essential part in providing nutrients for vertebral disc, important in maintaining vertebral biochemical integration with big role in vertebral growth. The main role of cartilaginous endplate is mechanical by preventing the bulging of the nucleus pulposus into the spongiosa of the vertebral body and functioning as a filter between the disc and vertebral body⁽¹¹⁾.

The prevalence of lumbar cartilaginous endplate (CEP) herniation detected by MRI among back pain patients in the present study was (52.2%). This finding was close to results of Kjaer et al⁽¹²⁾ study in Denmark which found a CEP herniation prevalence range of 25-50% in the 40 years population presented with back pain. However, our study was higher than that reported by Sahoo et al (13) study in India where 25.7% of CEP was detected by MRI. This difference

might be due to discrepancies in risk factors of CEP herniation between different communities in addition to the difference in the study design and sample size. Among Asian population, large population study conducted by Cheung et al ⁽¹⁰⁾ revealed that 40% of population under age of 30 years had lumbar intervertebral degeneration while more than 90% of population at 50-55 years age had lumbar intervertebral degeneration which is regarded as the most common cause of chronic low back pain. Joe et al ⁽⁸⁾ study in South Korea on 73 patients presented with low back pain through the period 2005-2009 showed that 50.6% of those patients show CEP herniation. Previous study in Germany (by Schmid) ⁽¹⁴⁾ reported that CEP herniation is highly related to maximizing pain intensity of disc herniation. Another study by Brock M ⁽¹⁵⁾ revealed that the multiple and recurrent sequestered parts of extruded discs are mainly of endplate material. Previous Japanese study by Yamada M ⁽¹⁶⁾ concluded that the CEP herniation is less absorbable than annulus fibrosus following spinal trauma.

The main MRI findings of patients with CEP herniation in this study are dorsal vertebral cornal defect, modic changes in mid endplate, modic changes in posterior corner, mid endplate irregularities, posterior osteophytes, lumbar posterior marginal nodes and heterogeneous signal intensity of extruded disc. These findings were similar to that reported by Roudsari and Jarvik ⁽¹⁷⁾ study in USA which stated that MRI is the best diagnostic method for intervertebral disc herniation and associated pathological changes. The modic changes in mid endplate in the present study were found among 65.2% of patients while the modic changes in posterior corner were found among 47.8% of the patients. Modic et al ⁽¹⁸⁾ stated that type 2 modic changes were the most common modic changes in herniated disc and represented about 90% of these changes; also he found that the modic changes are the predominant signs of CEP herniation. The modic changes in mid endplate of studied patients were significantly associated with CEP herniation detected by MRI ($p=0.03$). This finding was in agreement with results of Teichtahl et al ⁽¹⁹⁾ study in Australia which examined 72 patients with low back pain for modic changes and revealed that the common modic changes were type 2 with higher prevalent among patients with CEP

herniation. These signal intensity changes detected by MRI are considered as markers of morphological changes for diagnosing spinal degenerative diseases by MRI ⁽²⁰⁾.

Schmid et al ⁽²¹⁾ study in Germany found a significant correlation between MRI vertebral corner defects and CEP herniation. Inconsistently, Joe et al ⁽⁸⁾ study in South Korea detected no relationship between vertebral corner defects and CEP herniation and they explained this finding as the dorsal vertebral corner defects are covering the posterior corner of the vertebral body on MR images and it is not correlated to endplate degeneration.

The current study found that the most common level affected by MRI with disc and CEP herniation were L4-L5 and L5-S1. This finding was consistent with the results of Suthar et al ⁽²²⁾ in India which found that the most common degeneration and arthropathy of lumbar disc was at L4-L5 level followed by level L5-S1.

In the present study, the prevalence of CEP herniation detected by MRI was significantly increased with advanced age patients ($p<0.001$). This finding coincides with Moore et al ⁽²³⁾ study in Australia which reported that morphological changes of endplates are obvious with advanced age of population. In Brazilian study, lumbar spines extrusion was higher among patients in age group over 40 years old ⁽¹¹⁾. In elderly population, the CEP herniation had no specific criteria different from younger age population but the CEP herniation in this elderly population is the outcome of progressive disc degeneration ⁽²⁴⁾. These CEP morphological changes will lead to inhibition of nutrients supply and metabolites removal ⁽²⁵⁾ which in turn lead to higher lactate concentration affecting cell viability and matrix maintenance and accelerating the disc degeneration ⁽²⁶⁾.

Additionally, our study reported a highly significant association between lumbar posterior marginal nodes and CEP herniation ($p<0.001$) which was similar to results of Joe et al ⁽⁸⁾ study in South Korea which found that modic changes, lumbar posterior marginal nodes, endplate irregularities, dorsal vertebral corner defects and posterior osteophytes were prevalent signs of CEP herniation.

The diagnosis of CEP herniation is difficult and many cases were detected surgically so our study will help the Radiologist by adding information on demographic, clinical and MRI characteristics that are relevant to CEP herniation and increase their suspicion which lead to more concern on MRI signs

like modic changes and posterior lumbar nodes to detect the CEP herniation in earlier time and avoid the invasive diagnostic techniques and surgical interventions.

CONCLUSION:

The prevalence of lumbar cartilaginous endplate herniation detected by magnetic resonance imaging in patients with back pain is relatively high. CEP herniation is more likely to be prevalent among advanced age patients and at lower lumbar spinal level. The most common MRI signs related to cartilaginous endplate were modic changes in mid endplate and lumbar posterior marginal nodes.

REFERENCES:

1. Rajasekaran S, Bajaj N, Tubaki V. ISSLS prize winner: the anatomy of failure in lumbar disc herniation: an in vivo, multimodal, prospective study of 181 subjects. *Spine* 2013;38:1491–1500.
2. Veres SP, Robertson PA, Broom ND. ISSLS prize winner: how loading rate influences disc failure mechanics: a microstructural assessment of internal disruption. *Spine* 2010;35:1897–908.
3. Rodriguez AG, Slichter CK, Acosta FL. Human disc nucleus properties and vertebral endplate permeability. *Spine* 2011;36:512–20.
4. Ohtori S, Inoue G, Ito T. Tumor necrosis factor-immunoreactive cells and PGP 9.5-immunoreactive nerve fibers in vertebral endplates of patients with discogenic low back pain and modic Type 1 or Type 2 changes on MRI. *Spine* 2006; 31:1026–31.
5. Lotz JC, Fields AJ, Liebenberg EC. The role of the vertebral endplate in low back pain. *Global Spine J* 2013; 3:153–64.
6. Fields AJ, Rodriguez D, Gary KN, Liebenberg EC, Lotz JC. Influence of Biochemical Composition on Endplate Cartilage Tensile Properties in the Human Lumbar Spine. *Journal of orthopaedic research: official publication of the Orthopaedic Research Society* 2014; 32:245-52.
7. Kokkonen SM, Kurunlahti M, Tervonen O, Ilkko E, Vanharanta H. Endplate degeneration observed on magnetic resonance imaging of the lumbar spine: correlation with pain provocation and disc changes observed on computed tomography disk tomography. *Spine* 2002; 27:2274–78.
8. Joe E, Lee JW, Park KW, Yeom JS, Lee E, Lee GY, et al. Herniation of cartilaginous endplates in the lumbar spine: MRI findings. *AJR Am J Roentgenol* 2015; 204:1075-81.
9. Raj PP. Intervertebral disc: anatomy-physiology-pathophysiology-treatment. *Pain Pract* 2008; 8:18–44.
10. Cheung KM, Karppinen J, Chan D, Ho DW, Song YQ, Sham P, et al. Prevalence and pattern of lumbar magnetic resonance imaging changes in a population study of one thousand forty-three individuals. *Spine (Phila Pa 1976)* 2009; 34:934-40.
11. Herrero CFPS, Garcia SB, Garcia LV, Defino HLA. Endplates Changes Related to Age and Vertebral Segment. *BioMed Research International* 2014; Article ID 545017, 6 .
12. Kjaer P, Leboeuf-Yde C, Korsholm L, Sorensen JS, Bendix T. Magnetic resonance imaging and low back pain in adults: a diagnostic imaging study of 40-year-old men and women. *Spine (Phila Pa 1976)* 2005; 30:1173-80.
13. Sahoo MM, Mahapatra SK, Kaur S, Sarangi J, Mohapatra M. Significance of Vertebral Endplate Failure in Symptomatic Lumbar Disc Herniation. *Global Spine Journal* 2017; 7:230-38.
14. Willburger RE, Ehiosun UK, Kuhnen C, Kramer J, Schmid G. Clinical symptoms in lumbar disc herniations and their correlation to the histological composition of the extruded disc material. *Spine* 2004; 29:1655–61.
15. Brock M, Patt S, Mayer HM. The form and structure of the extruded disc. *Spine* 1998; 17:1457–61.
16. Carreon LY, Ito T, Yamada M, Uchiyama S, Takahashi H, Ikuta F. Histologic changes in the disc after cervical spine trauma: evidence of disc absorption. *J Spinal Disord* 2000; 9:313–16.
17. Roudsari B, Jarvik JG. Lumbar Spine MRI for Low Back Pain: Indications and Yield. *American Journal of Roentgenology* 2010; 195:550-59.
18. Modic MT, Steinberg PM, Ross JS. Degenerative disk disease: assessment of changes in vertebral body marrow with MR imaging. *Radiology* 1988; 166:193–99.

19. Teichtahl AJ, Urquhart DM, Wang Y, Wluka AE. Modic changes in the lumbar spine and their association with body composition, fat distribution and intervertebral disc height – a 3.0 T-MRI study. *BMC Musculoskeletal Disorders* 2016;17:92.
20. Zhang Y-H, Zhao C-Q, Jiang L-S, Chen X-D, Dai L-Y. Modic changes: a systematic review of the literature. *European Spine Journal* 2008; 17:1289-99.
21. Schmid G, Witteler A, Willburger R, Kuhn C, Jergas M, Koester O. Lumbar disk herniation: correlation of histologic findings with marrow signal intensity changes in vertebral endplates at MR imaging. *Radiology* 2004; 231:352–58.
22. Suthar P, Patel R, Mehta C, Patel N. MRI Evaluation of Lumbar Disc Degenerative Disease. *Journal of Clinical and Diagnostic Research : JCDR* 2015; 9:TC04-TC09.
23. Shafaq S, Muhammad AH, Khan RMA, Aisha R, Ahmad AA, Junaid A. Lumbar Disc Degenerative Disease: Disc Degeneration Symptoms and Magnetic Resonance Image Findings. *Asian Spine J.* 2013; 7:322–34.
24. Roberts S, Johnson WE. Analysis of aging and degeneration of the human intervertebral disc. *Spine* 2002; 24: 500- 501.
25. Gruber HE, Ashraf N, Kilburnetal J. Vertebralendplate architecture and vascularization: application of microcomputerized tomography, a vascular tracer, and immunocytochemistry in analyses of disc degeneration in the aging sand rat. *Spine* 2005; 30: 2593–2600.
26. Grunhagen T, Shirazi-Adl A, Fairbank JCT, Urban JPG. Intervertebral disk nutrition: a review of factors influencing concentrations of nutrients and metabolites. *Orthopedic Clinics of North America* 2011; 42 : 465–77.