

Prevalence of High Intensity Zone in Lumbar Spine and its Correlation with Lumbar Disc Degeneration in Patients Attending Tertiary Hospital of Eastern Nepal

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ABSTRACT

Introduction

A high intensity zone (HIZ) in intervertebral disc (IVD) of lumbar spine is a high intensity signal located in the annulus fibrosus of T2-weighted magnetic resonance (MR) imaging. There is limited information on the prevalence of HIZ in lumbar spine in Nepalese population. The aim of this cross-sectional study was to identify the prevalence of HIZ according to the age and its correlation with degenerated disc, disc herniation & bulge and modic changes.

Methods

This was a prospective MR based cross-sectional study in 268 patients (1380 IVD) with LBP, leg pain or numbness. Data was collected from the hospital database of radiology department where single blinding was maintained and was analysed using SPSS version 23.

Results

The prevalence of HIZ in patients with LBP was 30.5%. Degenerated disc was observed in 95% (116/122), disc herniation & bulge in 98.3% (120/122) and Modic changes in 11.4% (14/122) of the discs with HIZ.

Conclusion

There was statistically significant correlation between existence of HIZ and degenerated disc and disc herniation & bulge, but there was no correlation with the existence of Modic changes.

Keywords: disc degeneration; HIZ; low back pain.

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INTRODUCTION

A high intensity zone (HIZ) represents the detached nucleus pulposus which is trapped between the lamellae of torn annulus fibrosus, which causes a characteristic high signal change in magnetic resonance (MR) imaging, following inflammation.¹⁻³ The term HIZ was first described by April and Bogdok in 1992 with prevalence of 28% in symptomatic individual.¹ Prevalence of HIZ varies from 28-59% in symptomatic individuals but its identification in asymptomatic individuals has questioned its significance in clinical practice.⁴⁻¹⁰

To increase the diagnostic accuracy of HIZ, many authors now suggest to differentiate true HIZ from low/medium intensity zone depending on signal intensity on MR imaging.^{3, 5-8} The purposes of this study were to investigate: (i) the prevalence of HIZ in patients with LBP in different age groups and (ii) the correlation between HIZ and other degenerative findings on lumbar MR images (like disc degeneration, disc bulge & herniation and adjacent Modic changes).

METHODS

This was a prospective cross-sectional study. A total of 268 (n) consecutive patients were included from the hospital database of radiology department. All those patients who underwent MR imaging of the lumbar spine for symptoms like LBP, leg pain and numbness, between January 2020 to November 2020 were included in the study. Patients with infective spondylitis, tumor and who had history of surgery of lumbar spine were excluded. The study protocol was approved by the institutional review committee at Birat Medical College and Teaching Hospital

While collecting the data from the hospital database, single blinding was maintained. All the information required for the study was recorded in a separate paper for each participant and was double entered in the personal computer.

All patients were divided into 5 age groups <20 years, 20-39 years, 40-59 years, 60-79 years, >80 years. Prevalence of HIZ was calculated according to the above mentioned age groups. A 1.5 tesla MRI scanner (Signa Explorer, GE healthcare, Chicago, Illinois, USA) was used to acquire images, T1 weighted (335 <repetition time < 400 m/sec; echo time = 42m/sec) and T2 weighted (3000<repetition time<5000 m/sec; echo time = 120 m/sec) spine echo images were taken in the sagittal, coronal and axial planes. MR images had a slice thickness of 4 mm except axial were 3 mm.

HIZ was defined as a bright white signal located in the substance of the posterior or posterolateral annulus fibrosus, that was clearly dissociated from the nucleus pulposus and surrounded by the low intensity (black) signal of annulus fibrosus, and was appreciably brighter than that of the nucleus pulposus in T2-weighted sequence on MR images.¹⁻³ We differentiated true HIZ from low/medium intensity zone by presence of significantly high intensity signal which was as intense as cerebro-spinal fluid (CSF) signal located adjacent to the disc. (Figure 1). Along with that we also analysed statistical correlation between (i) HIZ and degenerated disc, (ii) HIZ and disc bulge & herniation (iii) HIZ and change in adjacent endplates i.e. Modic changes.

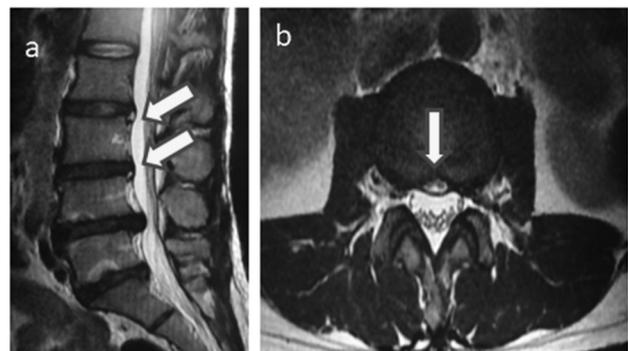


Figure 1. (a) Sagittal T2-weighted magnetic resonance image showing a high-intensity zone (arrows) within the posterior annulus at L2-3 and L3-4 (b) Axial T2-weighted magnetic resonance image showing a high intensity zone (arrow) within the posterior annulus at L3-4.

Disc degeneration was assessed on T2-weighted image on the basis of Pfirrmann grading system¹¹ as follows: grade 1: normal structure, no horizontal bands, clear distinction between annulus and nucleus; grade 2: inhomogeneous structure with horizontal bands, clear distinction between nucleus and annulus; grade 3: inhomogeneous structure with unclear distinction between nucleus and annulus, features of annulus still recognizable; grade 4: inhomogeneous structure with hypointensity, shape of annulus not intact and no distinction between nucleus and annulus, disc height usually decreased and grade 5: same as grade 4

using Chi-square test. For all of the statistical test $p < 0.05$ was considered statistically significant. Statistical analysis were performed using statistical package for social sciences (SPSS version 23.0 for window, SPSS. Inc. Chicago.IL).

RESULTS

Total 268 patients with low back pain were included in the study with 126 males and 142 females. The mean age of patient was 48.18 years (16-88 years). Eighty two (30.5%) patients had HIZ in at least one level of IVD. Most of the HIZ (93.4%) were observed in age group of 20-59 years (Table 1). Total 1340 lumbar intervertebral disc

Lumbar IVD	HIZ (%)	Degenerated disc (%)	Disc herniation & bulge (%)	Modic change (%)
L1-2	2 (3.2)	84 (11.3)	50 (7.2)	10 (5.4)
L2-3	22 (18)	116 (15.6)	92 (13.3)	16 (8.7)
L3-4	24 (19.6)	140 (18.8)	128 (18.6)	34 (18.6)
L4-5	54 (44.2)	204 (27.4)	236 (34.3)	72 (39.5)
L5-S1	18 (14.7)	198 (26.6)	182 (26.4)	50 (27.4)
Total	120	742	688	182

IVD: Intervertebral Disc, HIZ: High Intensity Zone

but disc space collapsed. For evaluation of data, Pfirrmann grade 1-3 were categorized as normal and grade 4-5 as degenerated disc.

Disc herniation & bulge were classified by Fardon et al.¹², where herniation was defined as disc displacement of disc material involving less than 50% of the disc circumference, and bulge was defined as disc displacement involving >50% of the disc circumference. Vertebral endplate and bone marrow changes were graded as absent, type 1 (hypointense in T1-weighted sequence and hyperintense in T2-weighted sequence), type 2 (hyperintense in both sequence) and type 3 (hypointense in both sequence) as defined by Modic et al.¹³ Difference of ratio were compared

(IVD) were evaluated for HIZ, disc degeneration, disc herniation & bulge and Modic changes. L4-5 IVD had maximum number of HIZ along with disc degeneration, disc herniation & bulge and Modic changes (Table 2).

Disc degeneration was observed in 95% (116/122) and 51.3% (626/1218) of disc with and without HIZ respectively. The prevalence of degeneration in disc with HIZ was significantly higher than that in disc without HIZ (Table 3). Disc herniation & bulge were observed in 98.3% (120/122) and 46.6% (568/1218) of the disc with and without HIZ, respectively. Prevalence of herniation & bulge in disc with HIZ was significantly higher than that in disc without

HIZ (Table 4). Modic changes were observed in 11.4% (14/122) and 13.7% (168/1218) of disc with and without HIZ respectively. No statistically significant difference was observed between the two groups (Table 5).

Age group (years)	0-19	20-39	40-59	60-79	>80	Total
HIZ in 3 IVDs	0	0	6	0	0	6
HIZ in 2 IVDs	0	10	18	0	0	28
HIZ in 1 IVD	0	18	22	8	0	48
HIZ absent	6	52	74	50	4	186
Total	6	80	120	58	4	268

HIZ: High Intensity Zone; IVD: Inter-Vertebral Disc

Table 2. Distribution of HIZ, Degenerated disc, disc herniation & bulge and Modic changes at each lumbar IVD.

Normal		Disc degeneration		Total
		Degenerated		
HIZ	Present	6	116	122
	Absent	592	626	1218
Total		598	742	1340

HIZ: High Intensity Zone

Table 3. Correlation between Disc degeneration and HIZ. P value=0.000

		Disc herniation & bulge		Total
		Present	Absent	
HIZ	Present	120	2	122
	Absent	568	650	1218
Total		688	652	1340

HIZ: High Intensity Zone

Table 4: Correlation between Disc herniation & bulge and HIZ. P value= 0.000.

		Modic changes				Total
		Absent	Present			
			Type 1	Type 2	Type 3	
HIZ	Present	108	2	12	0	122
	Absent	1050	12	152	4	1218
Total		1158	14	164	4	1340

HIZ: High Intensity Zone

Table 5: Correlation between Modic change and HIZ. P value= 0.669.

DISCUSSION

The presence of granulation tissue or neo-vascularisation induced by inflammation was first demonstrated by Ross et al.¹⁴ Such inflammatory granulation tissue produces pro-inflammatory cytokines and mediators which sensitize the neuroreceptors within the disc causing pain. These findings suggest that biomechanical mediators are more important than mechanical compression in the pathogenesis of DLBP.^{15, 16} Low/medium intensity zone can represent annular fissure in asymptomatic population.^{17, 18} In normal adult, the annulus fibrosus is innervated by the recurrent meningeal nerve and by branches from the ventral ramus of the somatic spinal nerve. Most of the nerve supply of the IVD is limited to the periphery of the annulus fibrosus.¹ Renkine et al.⁵ reported that maximum number of HIZ are present over posterior annulus followed by posterolateral annulus. It is because posterior annulus fibrosus is structurally weak and exposed to high stress concentration.²⁰

Bugdok¹⁸ and Liu et al.³ emphasized that HIZ must be an intense signal rather than any bright spot on T2weighted MR image. Schellhas et al.²¹ reported that 87% of the HIZ positive discs were concordantly painful on discography while 65 of 67 HIZ negative disc didn't elicit concordant pain on discography. Hence, concluded that the presence of HIZ was sign of internal disc disruption.

Takeuchi et al.¹⁰ evaluated prevalence of HIZ by age and correlation of HIZ with disc degeneration, disc bulge & herniation and modic changes. They concluded that there was no significant change in the prevalence of HIZ beyond the age of 20 years, although they have included only small number of patients aged

less than 20 years. They demonstrated close correlation of HIZ with disc degeneration, disc bulge & herniation in patients with LBP, leg pain or numbness. They anticipated that the diagnostic value of HIZ may be higher in patients under age of 20 years, but they had only two patients who had symptomatic HIZ in this age group. Jha et al⁷ identified that the presence of HIZ even in one IVD is directly proportional to increased incidence of disc degeneration in remaining lumbar IVD, mainly in the lower three lumbar discs. They predicted that HIZ positive patients are more susceptible for degeneration of adjacent level disc compared to HIZ negative patients. In their study of 43 HIZ positive patients out of 288 patients, 34 had single level HIZ positive disc and nine had multilevel HIZ with two levels in eight patients and three levels in one patient. They also demonstrated 87% had HIZ at posterior annulus and 13% had HIZ at postero-lateral annulus. Similarly, Lam et al²² demonstrated significant correlation between abnormal disc disruption and presence of HIZ . This study had few limitations, like we included

a very small number of patients representing age group less than 20 or more than 80 years which may contribute to the bias in statistics. Therefore a bigger sample population will be required in future studies. Secondly, it is difficult to say that the HIZ was the cause for LBP in these patients because LBP can be due to various other reasons such as osteoarthritis of facet joint, spinal deformities or the muscular cause etc.

CONCLUSIONS

Prevalence of HIZ in patients with LBP in Nepal is comparable to the literature worldwide. There is statistically significant relation between (i) HIZ and degenerated disc (ii) HIZ and disc bulge & herniation. More than 90% of HIZ were present in active age group of 20-59. Prevalence of HIZ, degenerated disc, disc herniation & bulge and Modic changes were mostly in the lower three lumbar IVD.

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