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RESEARCH

Prevalence and association of high-intensity lesions with degenerative processes in lumbar intervertebral discs

Lomber intervertebral disklerdeki yüksek yoğunluklu lezyonların prevalansı ve dejeneratif süreçlerle ilişkisi

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Abstract

Purpose: This population-based cross-sectional study examined the prevalence of high-intensity zones (HIZ) in the lumbar spine and their relationship to age, gender, disc degeneration, disc displacement (bulging or herniation), and facet joint degeneration.

Materials and Methods: A retrospective analysis was conducted on MRI studies of 800 patients (4000 discs) who were admitted to the hospital with subacute-chronic low back pain (LBP) and presented with axial pain (musculogenic-discogenic-mechanic) at outpatient clinics. The frequency of speed was determined by considering a total of seven age categories in decades. Correlation analyses were performed between HIZ and other variables.

Results: The prevalence of HIZ was 30%, highest in the >70 years age group and lowest in the <20 years age group. Significant correlations were found between these lesions and L2-3-4-5 level disc degeneration, L3-L4 level disc displacement, and L1-2-3 level facet joint degeneration. There was a significant correlation between HIZ and age, but not with gender. These lesions were most commonly associated with Grade 3 disc degeneration.

Conclusions: HIZ likely contributes to the development of discogenic LBP. The prevalence of HIZ was approximately 30%, with substantial age-related variations. A level-based association was observed between HIZ and disc degeneration, disc displacement, and facet joint degeneration in patients with LBP.

Keywords:. High-intensity zones, HIZ, disc degeneration, disc bulging, disc herniation, facet joint degeneration, MRI.

Öz

Amaç: Bu toplum tabanlı kesitsel çalışmanın amacı lomber omurgada yüksek yoğunluklu bölgelerin (YYA) yaygınlığını incelemek ve YYA ile yaş, cinsiyet ve disk dejenerasyonu, disk yer değiştirmesi (bulging veya herniasyon) ve faset eklem dejenerasyonu gibi diğer dejeneratif süreçler arasındaki korelatif ilişkileri araştırmaktır.

Gereç ve Yöntem: Subakut-kronik bel ağrısı (LBP) ile hastaneye başvuran ve polikliniklerde aksiyel yayılan (muskulojenik-diskojenik-mekanik) ağrısı olan 800 hastanın (4000 disk) MRG çalışmaları üzerinde retrospektif bir analiz yapıldı. YYA sıklığı, on yıllar içinde toplam yedi dekad içinde dikkate alınarak belirlendi. YYA ile diğer değişkenler arasında korelasyon analizleri yapıld.

Bulgular: YYA prevalansı %30 olup, >70 yaş grubunda en yüksek ve <20 yaş grubunda en düşüktür. Bu lezyonlar ile L2-3-4-5 seviyesinde disk dejenerasyonu, L3-L4 seviyesinde disk deplasmanı ve L1-2-3 seviyesinde faset eklem dejenerasyonu arasında anlamlı korelasyonlar bulunmuştur. YYA ile yaş arasında anlamlı bir korelasyon vardı, ancak cinsiyet ile yoktu. Bu lezyonlar en sık Evre 3 disk dejenerasyonu ile ilişkiliydi.

Sonuç: YYA muhtemelen diskojenik LBP gelişimine katkıda bulunmaktadır. YYA prevalansı yaşa bağlı önemli farklılıklar göstermekle birlikte yaklaşık %30'dur. LBP'li hastalarda YYA ile disk dejenerasyonu, disk deplasmanı ve faset eklem dejenerasyonu arasında seviyeye dayalı bir ilişki olduğu ortaya çıkarılmıştır.

Anahtar kelimeler: Yüksek yoğunluk alanları, YYA, disk dejenerasyonu, disk bulging, disk herniasyonu, faset eklem dejenerasyonu, MRG.

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INTRODUCTION

The initial use of the term "high-intensity zone" (HIZ) came about in 1992 to denote a lesion within the annulus fibrosus that manifests on MRI images as high-intensity signals[1]. Anatomical studies associate HIZ lesions with fibrous ring tears and the neovascular granulation tissue filling them. This mucus-like substance is responsible for the high signal intensity on magnetic resonance imaging (MRI) and is hypothesized to lead to an inflammatory response[2].

Compared to the fibrous ring tissue adjacent to the HIZ and normal controls, the expression levels of tumor necrosis factor-α (TNF-α) and macrophages (CD68) were considerably increased in the fibrous rings surrounding the HIZ[3]. Furthermore, these lesions were considered to be a good predictor for ethanol gel chemonucleolysis, which is considered a promising treatment for degenerative disc disease[4]. Age, obesity, and symptoms of low back pain (LBP) were found to be correlated with the presence of HIZ on the lumbar MRI[5].In contrast, some authors assert that HIZ lesions have limited diagnostic utility in patients with LBP[6,7].

The correlation between HIZ lesions and clinical symptoms has been the subject to several studies[8-13]; however, research examining the association with other degenerative processes of the spine is limited[14].

MRI-detected HIZ has been reported to be a very effective technique for screening lumbar intervertebral disc degeneration (IDD). Studies have shown that using a HIZ with consecutive slides is a more accurate signal for discogenic LBP compared to using a single-slide HIZ[15].

Anteriorly positioned HIZ lesions have been noted to be correlated with the process of aging and are less commonly found on lumbar MR imaging. Their spatial configuration differs from that of posterior HIZ lesions. A correlation has been observed between the anterior HIZ and LBP[16].

The objective of the present study was to assess the correlation between HIZ and other degenerative findings on lumbar MRI, including disc degeneration, disc bulging, herniation, and facet joint degeneration, as well as the prevalence and localization of HIZ by age in the lumbar spine.

MATERIALS AND METHODS

Sample

This research was a retrospective analysis of data collected at a single center from January 2022 to July 2023. Ethical approval was obtained from the Nisantasi University Ethics Board by its decision dated June 12, 2023 and numbered 2023/23. The study was conducted in the Orthopaedics and Traumatology Clinic of the BHT Clinic Istanbul Tema Hospital. Informed consent was obtained from the participants. We retrospectively examined the medical records of 884 patients who presented with complaints of low back pain. Patients who underwent a lumbar MRI and were outpatients older than 18 years with symptomatic subacute-chronic-axiel LBP met the inclusion criteria. Patients who had previously undergone surgical procedures and had received a diagnosis of infectious spondylitis, tumors, or scoliosis were all excluded from this study.

In cases where a patient had two or more recordings, only the most recent one was utilized. Out of the 884 participants, 84 individuals who fulfilled the exclusion criteria or did not have MRI scans were excluded. A total of 800 patients, comprising 364 males and 436 females, who met the inclusion criteria, were enrolled in this study.

The patients were categorized into five age groups. <20 years (n = 36), 20–29 years (n = 120), 30–39 years (n = 152), 40–49 years (n = 208), 50–59 years (n = 140), 60–69 years (n = 96), and >70 years (n = 48). The calculation of the prevalence of HIZ was stratified by age group.

MRI Assessment

Each patient's axial and midsagittal T2W sections were acquired and subsequently anonymized. Lumbar spine MRIs were performed utilizing a 3-T scanner (GE, Signa, 3-T). This investigation employed merely axial and sagittal T2W images. A fast spin-echo sequence was employed to obtain T2W sagittal images. This sequence prescribed an echo train length of 25 and a repetition time ranging from 2680 to 4900 ms, an echo time of 100–104 ms, and an echo train length of 25. DFOV was 30 x 30 cm, and the thickness of each slice was 4 mm. With a repetition time of 2839–5964 msec, an echo time of 117–120 msec, and an echo train length of 17, axial T2W images were acquired. The DFOV measured 18 by 18 cm, and the slice thickness was 4 mm.

Radiological evaluation

HIZ is identified on T2-weighted sagittal MRI as a noticeable bright white signal within the posterior annulus fibrosus. It is significantly brighter than the nucleus pulposus and can be easily differentiated from it due to its location which is surrounded by the low-intensity (black) signal of the annulus fibrosus. As per the classification of Teraguchi et al., HIZ lesions were categorized[17](Fig. 1).

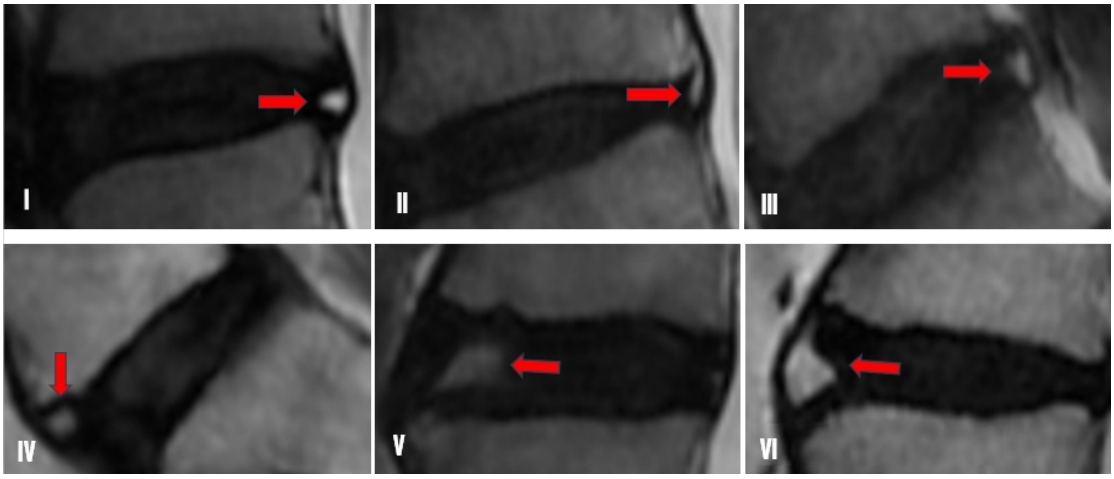

Figure 1. Topographic and morphologic classification of HIZ lesions. (I) posterior round type, (II) posterior fissure type, (III) posterior vertical type, (IV) anterior round type, (V) anterior rim type, (VI) anterior enlarged type.

Disc displacement was classified as either herniation or bulging according to Fardon et al.'s classification of disc displacement[18]. Herniation was operationally defined as the displacement of disc material that did not encircle the disc by more than 50%. Bulging was operationally defined as the displacement of disc material that exceeded 50% of the circumference of the disc. The degree of degeneration of each disc was evaluated in accordance with the Pfirrman classification on the basis of the MRI results[19]. This determination was made jointly by an independent radiologist and a spine surgeon with ten years of experience. Discs of grades 1 and 2 were regarded as non-degenerated, whereas those of grades 3–4-5 were regarded as degenerated. A consensus among the same clinicians graded facet joint degeneration at all lumbar levels in all patients in accordance with the Weishaupt classification[20]. Grade 0 and 1 facets were deemed non-degenerated; grade 2 and 3 facets were deemed degenerated[21].

Statistical analysis

In order to analyze the data, frequency and percentage statistics were applied. Furthermore, chi-square analysis was implemented to investigate the variations among the categories. One of the correlation techniques, Cramer V statistics, was applied to examine the association between categorical variables. During the analysis phase, the age variable, which was initially collected as a continuous set, was converted into a categorical one. In each of the statistical experiments, a significance level of $P<0.05$ was applied. The statistical analyses were conducted utilizing the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, version 23.0 for Windows).

When the effect size analysis was performed on the sample in line with the purpose of the research, it was determined that the minimum required sample size was 133. The conditions determined for the power analysis were alpha level 0.05, beta level (second type of error) 0.20, medium effect size, and two-way hypothesis. When the data for the study were collected, more people were reached than the sample size determined for the effect size. Power analysis was carried out through the Gpower (version 3.1.9.7) package program.

RESULTS

240 (30%) of 800 patients had HIZ lesions in at least one disc (36 had multi-level, 204 had single-level). Out of 36 patients with multilevel HIZ, 12 had 3 levels and 24 had 2 levels. The distribution of HIZ lesions is given in Table 1.

Patients ranged in age from 18 to 84 years (mean 49.4 years.; SD 16.0). According to age groups, the rate of HIZ lesions was lowest in the <20-year-old age group and highest in the >70-year-old age group. However, this increase was not statistically significant (p = 0.12-0.42). Table 2 shows the prevalence data on the relationship between age groups and HIZ lesions.

Table 1. HIZ lesion type and level-based distribution.

		LUMBAR İNTERVERTEBRAL DİSCS					
TYPE	**n (%)**	**L1-2**	**L2-3**	**L3-4**	**L4-5**	**L5-S1**	**n (%)**
Posterior Round	152(52.77%)	12	16	12	48	64	152(52.77%)
Posterior Fissure	60(20.83%)			8	20	32	60(20.83%)
Posterior Vertical	28(9.73%)	-	-	-	16	12	28(9.73%)
Anterior Round	32(11.11%)	-	8	16	8	-	32(11.11%)
Anterior Rim	4(1.39%)	-	-	4	-	-	4(1.39%)
Anterior Enlarged	12(4.17%)	-	4	8	-	-	12(4.17%)
Total	288(100%)	12	28	48	92	108	288(100%)

Table 2. Patients with HIZ according to age

		HIZ				
Age, years	n	present	absent	%	*p*	
< 20	36	4	32	11.1%	---	
20-29	120	28	92	23.3%	0.426	
30-39	152	44	108	29%	0.270	
40-49	208	72	136	34.6%	0.160	
50-59	140	40	100	28.6%	0.281	
60-69	96	32	64	33.3%	0.202	
≥ 70	48	20	28	41.6%	0.125	
Total	800	240	560	30%	0.724	

When the discs were analyzed by level, both HIZ lesions and disc degeneration were most common at the L5-S1 level (38.8% and 23.6%, respectively). Disc bulging and herniation were most common in the L4-L5 disc (38.1% and 43.1%, respectively). Data regarding the level-based distribution are given in Table 3.

The rate of HIZ lesions was 72.22% in discs with degeneration and 27.78% in discs without degeneration. The difference was statistically significant (p = 0.005; rv=0.09). HIZ lesion rates in discs with and without disc bulging were 30.56% and 69.44%, respectively. The rates of HIZ lesions in discs with and without disc herniation were 25% and 75%, respectively. The frequency of HIZ lesions concomitant with and without facet degeneration was 77.8% and 22.2%, respectively. There was a significant positive correlation between HIZ lesion and disc bulging, disc herniation, and facet degeneration, and this correlation was low (p = 0.00; rv=0.16 and p=0.031; rv=0.07, p=0.00; rv=0.20 respectively). Table 4 shows the prevalence values and correlation analysis results

Table 3. The proportion of Lumbar Discs with HIZ, degeneration, and displacement status.

DİSC	HIZ+	Degenerated	Non Degenerated	Total	Bulging	Herniated	No Displacement	TOTAL
L1-2	12(4.1%)	372(16.3%)	428(24.8%)	800	24(5%)	4(0.8%)	772(25.1%)	800
L2-3	28(9.7%)	392(17.1%)	408(23.7%)	800	40(8.4%)	32(6.8%)	728(23.7%)	800
L3-4	44(15.2%)	452(19.8%)	348(20.2%)	800	72(15.2%)	80(17.2%)	648(21.1%)	800
L4-5	92(31.9%)	524(22.9%)	276(16%)	800	180(38.1%)	200(43.1%)	420(13.7%)	800
L5-S1	112(38.8%)	540(23.6%)	260(15.1%)	800	156(33%)	148(31.8%)	496(46.1%)	800
TOTAL	288	2280	1720	4000	472	464	3064	4000

Table 4. Correlation between HIZ and disc degeneration, disc bulging, disc herniation and facet degeneration.

Disc Degeneration						
		Grade 1-2	Grade 3-4-5		*p*	Cramer V(rv)
HIZ	Present	80 (%27.78)	208 (%72.22)		0.005*	0.09**
	Absent	1708 (%46.01)	2004 (%53.99)			
	Total	1788	2212			
Disc Bulging						
		Present	Absent	Total	p	Cramer V
HIZ	Present	88 (%30.56)	200 (%69.44)	288	0.000*	0.16**
	Absent	384 (%10.34)	3328 (%89.66)	3712		
	Total	472	3528	4.000		
Disc Herniation						
		Present	Absent	Total	p	Cramer V
HIZ	Present	72 (%25.00)	216 (%75.00)	288	0.031*	0.07**
	Absent	392 (%10.88)	3212 (%89.22)	3604		
	Total	464	3536	4.000		
Facet Degeneration						
HIZ		Present	Absent	Total	*p*	Cramer V
	Present	224 (%77.80)	64 (%22.20)	288	0.000*	0.20**
	Absent	1484 (%40.00)	2228 (%60.00)	3712		
	Total	1708	2292	4.000		

*Chi-square $p<0.05$ **Cramer V, rv(>0.05 weak; >0.10 moderate; >0.15 strong; >0.25 very strong)[22]

Table 5. Results of correlation analyses between HIZ and other variables on a level basis.

	HIZ vs Disc Degeneration		HIZ vs Bulging/Herniation		HIZ vs Facet Degeneration	
	p	r	p	r	p	r
L1-2	0.6	0.24	0.898	0.02	0.03*	0.23
L2-3	0.00*	0.46	0.489	0.09	0.009*	0.27
L3-4	0.002*	0.29	0.003*	0.29	0.04*	0.19
L4-5	0.00*	0.28	0.004*	0.26	0.6	0.19
L5-S1	0.001*	0.29	0.594	0.23	0.58	0.19
Total	0.005*	0.09	0.00*	0.21	0.00*	0.20

There was a significant positive correlation between HIZ and disc degeneration at the L2-3–4-5 levels, while an association between HIZ and bulging or herniation was observed only at the L3 and L4 levels. There was a positive correlation between HIZ and facet degeneration only at L1-L2 and L3 levels.

*Chi-square $p<0.05$; r (>0.05 weak; >0.10 moderate; >0.15 strong; >0.25 very strong)[22]

When analyzed on a level basis, a significant positive correlation was observed between HIZ lesions and L2-3-4-5 disc degeneration. No relationship was seen on the L1 disc. There was a significant relationship between HIZ lesions and L1-2-3 level FD, but not between L4-5 facet degeneration. There was a significant correlation between HIZ lesions and both disc bulging and disc herniation at the L3–4 level, but not at other levels. Correlation values are given both level-based and total in Table 5. Moderately positive relationship was seen between disc degeneration and age (p=0.00; rv=0.37-0.46). There was a significant positive correlation between facet joint degeneration and age; the relationship was moderate (p=0.00; rv=0.45-0.57). A moderately strong, significant positive association was observed between HIZ lesions and age only for HIZ lesions in L1 and L2 discs (p=0.00-0.02; rv=0.33-0.36). No correlation was found between age and HIZ lesions in L3–4-5 discs.

HIZ lesions were most commonly associated with grade 3disc degeneration (p=0.005; rv=0.18). No significant correlation was observed between HIZ lesions and gender (p = 0.07–0.657).

DISCUSSION

The prevalence of HIZ is reported to be between 14% and 63%, and it shows a great variety[2,5,8,17,23]. According to some studies, these lesions are not indicative of disc degeneration; rather, they are indicative of an integrity issue and bulging[2]. However, a substantial correlation between HIZ and disc degeneration has been established in the majority of studies[8-11]. Consistent with the majority of studies in the literature, we demonstrated a correlation between HIZ lesions and disc degeneration at the L2-L5 levels in our research. In their study, Zehra U et al. found no statistically significant correlation between HIZ lesions and disc herniation[12]. In contrast, the correlation between HIZ lesions and disc degeneration, protrusion, and herniation was demonstrated by Takeuchi et al. in their investigation of the relationship between these three processes[13]. Furthermore, it has been hypothesized that HIZ lesions could potentially compromise the integrity of the surrounding tissue, resulting in the creation of annular fissures that could contribute to the subsequent occurrence of disc extrusion[24]. Our findings confirmed the correlation between HIZ lesions and bulging and herniation, which is consistent with the results of these studies. Furthermore, our research demonstrated a correlation between disc degeneration at the L2-L5 levels and HIZ lesions. In line with existing research, our study did not find any correlation between gender and HIZ lesions[6,9].

The relationship between these lesions and clinical findings has also been investigated. There are studies associating these lesions with LBP[8]and advanced age[17,25]. These lesions have also been reported to be associated with abnormal disc morphology on discography[26].The connection between HIZ lesions and facet joints has also been the subject of research. Facet joint degeneration and other forms of spinal degeneration were not linked to the presence of HIZ lesions in one investigation[14]. The correlation between the presence of HIZ lesions and facet joint degeneration at the upper level was observed in our study. However, no correlation was found with facet arthrosis at the lower two levels. There are studies indicating that HIZ lesions are a possible risk factor for LBP. Dutta et al. reported a significant increase in low back pain in patients with HIZ lesions on MRI and found 63% more intraoperative annular tears in these patients[27]. Wang HQ et al. and Carragee et al. have also associated LBP with HIZ lesions[8,28]. On the contrary, it has been proposed that HIZ and LBP do not exhibit any correlation. Prospective studies have also been conducted to determine the effect of HIZ lesions on the long-term outcome of LBP treatment. Kleinstruck et al. reported that the presence of disc degeneration and disc bulging did not have a significant negative effect on long-term outcomes in conservatively treated LBP patients, but the presence of HIZ lesions at any level was associated with less pain on average in the long term[29]. Kasch et al reported no significant association between lumbar degenerative changes, including HIZ lesions, and LBP, both at baseline and at long-term follow-up[30].Wilkens et al. found no association between HIZ lesions and future disability[31]. In a similar vein, Hellum et al. reported no correlation between the existence of HIZ lesions and long-term disability outcomes in patients who underwent conservative or surgical treatment[32].The potential prognostic consequences of HIZ lesions could not be addressed in our investigation because we did not have a prospective design resembling the studies cited.

We have some limitations. First, a small number of patients below the age of 20 was incorporated, potentially introducing a source of bias into the statistical data. Therefore, future research must utilize

a more comprehensive sample population. Further, our research design was cross-sectional in nature, and it comprised exclusively of patients who were hospitalized with lumbar pain. None existed as a control group. As a result, it was unclear how HIZ lesions affected LBP, which could be attributed to a variety of factors. Thirdly, because the research was retrospective and radiologically based, clinical variables including body mass index (BMI), severity of pain, and treatment responses were not incorporated.

In conclusion, this is a cross-sectional and retrospective study systematically assessing the rate of HIZ lesions. A level-based association is established between the presence of HIZ on the lumbar MR image and the following conditions: aging, disc degeneration, disc displacement (bulging or herniation), and facet joint degeneration. As a result, we believe that the data obtained in this study may provide important information on the prevalence of HIZ lesions for orthopaedists, neurosurgeons, radiologists, and therapists. When the presence of these lesions is recognized, it may draw attention to more careful observation of other degenerative processes that may accompany them. These results are comparable to other published data.

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