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The relationship between intervertebralis disc height and pfirrmann's degenerative degree: In lumbar degenerative disease patients performed surgery at Dr. Soetomo general academic hospital period of 2016-2021

Endra Wibisono Harmawan
Neurosurgeon, Department of Neurosurgery, Faculty of Medicine, Airlangga University- Dr. General Academic Hospital, Surabaya, Indonesia

Muhammad Arifin Parenrengi
Head of Department of Neurosurgery, Faculty of Medicine, Airlangga University- Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
*Corresponding author email: muhammad.arifin@fk.unair.ac.id

Abdul Hafid Bajamal
Professor of Neurosurgery, Department of Neurosurgery, Faculty of Medicine, Airlangga University- Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Eko Agus Subagio
Staff of Spine Neurosurgeon, Department of Neurosurgery, Faculty of Medicine, Airlangga University- Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Sri Andreani Utomo
Staff of Neuroradiologist, Department of Radiology, Faculty of Medicine, Airlangga University- Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Budi Utomo
Staff of Statistics lecturer, Department of Public Health and Preventive Medicine, Faculty of Medicine, Airlangga University- Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

***Abstract*---**This study aims to determine the relationship between disc height as objective data and the degree of disc degenerative Pfirrmann score assessed on MRI imaging, the imaging modality with the best current degenerative lumbal disease's diagnosis. The measurements of

disc height and Pfirrmann degenerative degree of the intervertebral disc were performed on a T2WI MRI sequence, sagittal sections of the 1-2 lumbar intervertebral discs to 5-sacral 1 (5 disc levels) using dicom MRI data using the Horos dicom viewer software. Analysis of the correlation between disc height and the degree of degeneration on MRI was performed using the Pearson correlation test. Statistical tests were performed using SPSS software (SPSS Inc., Chicago, IL, USA). The results were evaluated with a significance value of $p<0.005$. The results of the Pearson test in the three groups of patients, namely in the HNP L4-L5, HNP L5-S1 and HNP patient groups at both disc levels showed an inverse relationship between disc height and Pfirrmann's degenerative degree which was statistically significant, with values in the L4 HNP group. -L5 Pearson correlation $r = -0.729$ ($p<0.001$), in the HNP group L5-S1 Pearson correlation $r = -0.876$ ($p<0.001$) and in the HNP group L4-L4 + L5+S1 Pearson correlation $r = -0.970$ ($p <0.001$).

***Keywords*---**disc height, disc degenerative disease, pfirrmann grading.

Introduction

The Global Burden of Disease 2019 reports Low Back Pain (LBP) as a disease that ranks fourth in the 10 most common diseases aged 25-49 years. LBP is a global problem that often occurs, with a global prevalence in 2019 of 7.5% of the total world population. Lifetime prevalence of high LBP is up to 84% and around 11-12% causes disability. LBP has been the main cause of disability in the world's population / Years Lived with Disability (YLD) since 1990 and continues to increase until now and is highest in the 50-54 year age group. Conditions in the United States, the economic burden due to LBP causes losses of 84.1 to 624.8 million US dollars annually, which is used, among others, for medical purposes, insurance, decreased production capacity and benefits provided to patients with disabilities. (Jiang and Chen, 2018; Che et al., 2019; Collaborators, 2020; Wu et al., 2020; Zileli et al., 2020; Williamson and Smith, 2021).

The intervertebral disc is an important tissue structure for maintaining spinal function. This network has the ability to maintain spinal stability (stability) under various conditions of load received, while maintaining movement between spinal segments (mobility). The lumbar disc undergoes destructive changes and degeneration with age, but this process can be triggered by several risk factors, including obesity, smoking history and occupational history. There is a close relationship with the condition of the occurrence of LBP due to degeneration of the intervertebral disc, known as Intervertebral Disc Degeneration (IVDD). Disc degeneration begins with a tear in the annulus when the load-bearing process is disrupted. Degenerative disc causes disc protrusion, osteophyte formation, loss of disc height, and nerve compression and irritation. In advanced degeneration, the disc will lose water content and cause segmental instability and cause degenerative spondylosis and scoliosis. Advanced degenerative changes affect the facet joints and surrounding soft tissues, resulting in narrowing of the canal also known as degenerative canal stenosis. Intervertebral disc degeneration is a complex process of cell-mediated structural changes and is a chronic process

throughout life that most often occurs in the third and fourth decades of life. (Kim et al., 2018; Hebelka et al., 2019; Johnson and Shah, 2019; Yates et al., 2020; Hutchins et al., 2021; Williamson and Smith, 2021).

The use of MRI to evaluate the morphology of the intervertebral disc has a sensitivity ranging from 70-100% and a specificity of 65-97%. Its widespread use has good intraobserver agreement on statistical reproducibility tests, especially in the assessment of spondylolisthesis, disc degeneration, Modic changes and facet arthropathy. The important role of imaging in the management of LBP is to identify and exclude pathological conditions in planning future therapeutic strategies. The method of assessing the degree of disc degeneration that can be used in MRI imaging, proposed by Pfirrmann in 2001, is reliable for assessing degeneration of the intervertebral disc. The degenerative degree Pfirrmann's grading observed the signal intensity of the T2 MRI sequence as a hypointensity picture of the loss of water content, proteoglycans and collagen found in intervertebral disc degeneration, the morphological parameters were divided into five degenerative degrees in the disc (5-point grading system). The systematic review studies that have been carried out show that Pfirrmann's grading is the method of choice because it is comprehensive and can be widely used in clinical assessments with good reproducibility tests. (Pfirrmann et al., 2001; Jiang and Chen, 2018; Fyllos et al., 2018; Che et al., 2019; Song et al., 2019).

Disc height is a variable that can be assessed on both x-ray and MRI imaging. In degenerative cases, plain x-ray can help identify changes in the anatomy of the disc on a macro basis, especially well seen on a lateral view, however, MRI is still the standard imaging modality to identify various pathologies of the disc, including disc height. The advantages of MRI include non-invasive imaging without ionizing radiation, the ability for multiplanar imaging and accuracy in identifying changes in disc structure, as well as having good inter-rater agreement and study reliability in measuring disc morphology. The multiplanar imaging capability of MRI facilitates the assessment of disc degeneration and its subsequent sequelae, including annulus tears, disc protrusion, disc extrusion, osteophyte formation, spinal canal narrowing, narrowing of the lateral recess to disc height narrowing, where the morphology of the disc is closely related to the incidence of LBP. . The use of MRI in determining disc height has several advantages, including providing a clearer endplate boundary demarcation as the basis for measuring height with the help of multiplanar images that allow measurements in the midsagittal section, this is a limitation in the use of x-rays which is influenced by the ability of the radiographer to obtain images. true lateral as one of the requirements of a good disc height measurement. The current condition is that not all health care centers are equipped with MRI facilities as a diagnostic tool, so the use of x-rays is still one of the modalities in the initial diagnosis of suspected lumbar degenerative diseases. (Elfering et al., 2002; Frobin et al., 2015; Suthar et al., 2015; Teichtahl et al., 2015).

This study aims to determine the relationship between disc height as objective data and the degree of degenerative Pfirrmann disc as assessed on MRI imaging. The relationship found is expected to help establish an early diagnosis of lumbar degenerative disease in areas or health centers that only have x-ray imaging, by measuring the height of the disc as an indication of degenerative disorders.

Publication of objective data on disc height in degenerative diseases is also still lacking. (Ekedahl et al., 2018; Bach et al., 2019; Varlotta et al., 2019; Vargas, Boto and Meling, 2021)

Method

Study Design

This study is a retrospective analytical study that analyzes the relationship of research variables. This research has ethical clearance which has been issued by the Health Research Ethics Committee of Dr Soetomo General Academic Hospital Surabaya with letter no 0386/LOE/301.4.2/III/2021.

Population, Sample, and Sampling Technique

The population of this study were patients who were hospitalized and had spinal surgery performed by the Spine Division of the Department of Neurosurgery Dr. Soetomo Hospital Surabaya between 2016 – 2021. The sample of this study is the research population that has been screened according to the inclusion and exclusion criteria used. The desired minimum sample size is obtained based on the Snedecor and Cochran formula

Research Inclusion Criteria

Patients older than 18 years. Diagnosed with lumbal degenerative disease. The patient was hospitalized and had a surgery performed by the neurosurgeon of Dr Soetomo Hospital Surabaya between 2016-2021. Have a preoperative lumbar MRI examination conducted at the Radiology Unit of Dr Soetomo Hospital**.**

Research Exclusion Criteria

Patients less than 18 years of age. Does not have complete medical record data. Does not have a preoperative lumbar MRI examination performed at the Radiology Unit of Dr Soetomo Hospital. Patients diagnosed with infection, spinal trauma, spinal tumor, disc calcification, upward disc migration and canal stenosis with causes other than HNP. Patients with a history of previous orthopedic surgery and congenital abnormalities of the spine.

Source of information and Research Instruments

The material in this study was data from a lumbosacral MRI dicom from a patient sample, to measure the height and characteristics of the degree of degeneration. Dicom was obtained from the GE Healthcare Optima MR350 1.5 Tesla MRI machine, with the protocol (thickness : 3 mm; interslice distance 1.5 mm; repetition time 2000 ms, field of view 281 × 281 mm, image resolution 0.366 mm per pixel). Medical record data as a secondary source of information on research variable data on research sample patients. The research instruments include the Horos DICOM Viewer for MACbook software, a software to read and take measurements of MRI dicoms and Microsoft Office and SPSS software (SPSS Inc., Chicago, IL, USA), as a tool for writing and analyzing research data.

Research Locations and Time

The location of data collection and calculation of research was carried out in the medical record room and in the radiology installation of the Diagnostic Center Building Dr Soetomo Hospital. Data collection is carried out according to the validity period of the published ethical clearance, starting from March 1, 2021 to March 1, 2023.

Procedure for Data Collection

The disc height measurements were performed on a T2WI MRI sequence, sagittal sections of the 1-2 lumbar intervertebral discs to 5-sacral 1 (5 disc levels) using dicom MRI data using the Horos dicom viewer software. Disc height measurement refers to the study of Fyllos et al. 2018 regarding the morphometry of the adult lumbar disc so that it was obtained at the anterior, medial and posterior points on the midsagittal MRI section. The point is then averaged to measure the overall disc height. The schematic can be seen in Figure 1. The measurement results are then discussed together by a neurosurgeon and a neuroradiologist. (Fyllos et al., 2018).

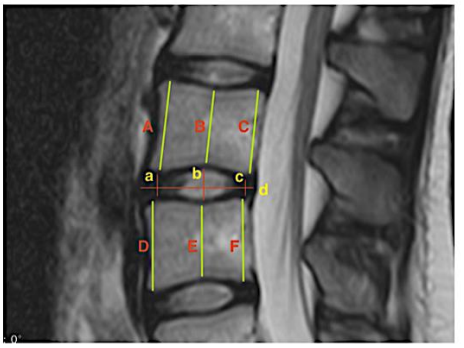


Figure 1. Schematic of disc measurement points. On the midsagittal MRI of the lumbar level. A/D = anterior vertebral column height; B/E = medial vertebral column height; C/F = posterior vertebral column height; a = anterior disc height; b = medial disc height; c = posterior disc height; d = disc diameter. (Fyllos et al., 2018)

The measurement of the degenerative degree of the intervertebral disc was assessed from the sagittal MRI of the T2WI sequence using the Pfirmann score method. The assessment was carried out by the researcher and in joint discussion with the neurosurgeon and neuroradiology specialist. Illustration of the use of the Pfirrmann score carried out in the study of Farshad et al. 2015 can be seen in Figure 2. (Farshad-Amacker et al., 2018).

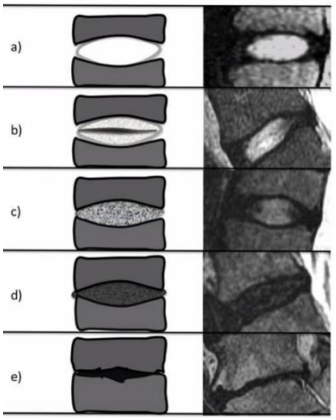


Figure 2. Pfirrmann degenerative rating scheme. In the midsagittal section of the T2WI sequence. (a) grade-I, homogeneous disc, hyperintense and normal disc height; (b) grade-II, inhomogeneous, hyperintense disc with distinguishable annulus and nucleus and normal disc height; (c) grade-III, inhomogeneous, gray disc border of the nucleus and annulus is not clear, disc height can be normal or slightly reduced; (d) grade-IV inhomogeneous, hypointense disc with nucleus and annulus difficult to distinguish, disc height may be normal or reduced; (e) grade-V inhomogeneous, blackish disc hypointense with collapsed disc height. (Farshad-Amacker et al., 2018)

Data Analysis

The data obtained from each research variable will be analyzed and presented in the form of tables, pictures and graphs as well as written information. Descriptive analysis was performed using statistical measures (mean, standard deviation, proportion and frequency distribution table) on each variable including age, sex, symptom and symptom onset as well as the distribution of disc height distribution from the study sample. Independent t-test was used to compare each group being measured. Analysis of the correlation between disc height and the degree of degeneration on MRI was performed using the Pearson correlation test. Statistical tests were performed using SPSS software (SPSS Inc., Chicago, IL, USA). The results were evaluated with a significance value of $p<0.05$

Results

Characteristics of Research Sample

The total population obtained was 401 patients with research samples included in the study according to the inclusion and exclusion criteria of 100 patients, according to the minimum number of samples that had been calculated as 96 patients. The excluded data included 66 cases of tumors, 63 cases outside the lumbar vertebrae level, 51 cases of infection, 19 cases with a history of previous surgery, 75 cases of trauma and a total of 27 cases of lumbar HNP that did not have MRI dicom data on a search at the radiology installation of Dr. Soetomo Hospital.

Demographic data in the study sample obtained from medical records included age, gender, clinical symptoms and onset of symptoms. One hundred patients in the study sample consisted of 57 men and 43 women with an average age of 54.44 (± 12.62) years. The total number of discs measured was 500 disc levels, consisting of each lumbar disc segment, namely Lumbar (L) 1-L2, L2-L3, L3-L4, L4-L5 and L5-S1, where HNP occurred in the L4-L5 segment. , L5-S1 or both as many as 123 disc levels. Characteristics of HNP and patient demographics can be seen in table 1.

Table 1
Summary of patient sample demographics and characteristics of HNP

Description	Total
Number of Patient Samples	100
- HNP DISC L4-L5	64
- HNP DISC L5-S1	13
- HNP DISC (L4-L5 + L5-S1)	23
Sex	
- Male	57 (57%)
- Female	43 (43%)
Age (years)	
- RANGE	21-82
- MEAN	54,44
- STANDARD DEVIATION	± 12,62
Clinical Symptoms (n=100)	
- RADICULAR PAIN	100 (100%)
- CLAUDICATIO INTERMITTENT	67 (67%)
- HIPOESTESIA	51 (51%)
- MOTORIK WEAKNESS	24 (24%)
- URINE INCONTINENSIA	3 (3%)
Onset of Symptoms (months)	
- MEAN	12,62
- STANDARD DEVIATION	±14,19

The size of the disc height of HNP patients L4-L5

Measurement of disc height in the L4-5 HNP patient group with a total sample of 64 people, consisting of 35 men and 29 women. In the male group, the mean disc height can be divided into 7 groups according to age decade. The mean disc height at L1-L2 levels from anterior, mid and posterior measurements in the male sex group was 7.754 0.5 mm (decade 2), 8.343 0.8 mm (decade 3), 8.214 0.6 mm (decade). 4), 7.980 0.6 mm (decade 5), 7.931 0.6 mm (decade 6), 7.737 0.4 mm

(decade 7), and 7.612 0.5 mm (decade 8). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to the decade of age in men can be seen in Table 2. In the female group, the mean disc height can be divided into 6 groups according to the decade of age. The mean disc height at L1-L2 levels from anterior, mid and posterior measurements in the female sex group was 5.737 0.6 mm (decade 2), 8.082 1.0 mm (decade 3), 8.105 1.0 mm (decade). 4), 7.953 0.8 mm (decade 5), 7.836 0.8 mm (decade 6), and 7.582 1.4 mm (decade 7). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to the decade of age in men can be seen in table 3.

Table 2
Disc height of male samples of HNP patients L4 – L5 (mean ± SD in mm). n = 35

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 1	Decade 3 n = 5	Decade 4 n = 5	Decade 5 n = 8	Decade 6 n = 12	Decade 7 n = 3	Decade 8 n = 1	p
L1-L2	Anterior	-	7,682	8,298	8,751	8,074	8,203	7,965	8,029	
	Mid	-	8,377	9,185	8,390	8,507	8,390	7,966	7,752	
	Posterior	-	7,204	7,545	7,503	7,358	7,201	7,279	7,054	
	Mean	-	7,754 ± 0,5	8,343 ± 0,8	8,214 ± 0,6	7,980 ± 0,6	7,931 ± 0,6	7,737 ± 0,4	7,612 ± 0,5	0,193
L2-L3	Anterior	-	8,879	8,555	8,095	8,769	9,255	8,471	8,045	
	Mid	-	10,31	9,080	8,483	8,788	8,693	8,367	8,001	
	Posterior	-	7,806	7,773	7,095	7,393	7,362	7,497	7,681	
	Mean	-	8,343 ± 0,7	8,469 ± 0,6	7,891 ± 0,7	8,317 ± 0,8	8,437 ± 1,0	8,112 ± 0,5	7,909 ± 2,0	0,287
L3-L4	Anterior	-	10,88	8,636	8,907	9,967	9,454	8,700	7,831	
	Mid	-	10,64	9,398	8,814	9,609	9,498	8,380	8,011	
	Posterior	-	9,819	7,805	8,015	7,952	6,688	7,171	7,345	
	Mean	-	10,44 ± 0,5	8,613 ± 0,8	8,578 ± 0,5	9,176 ± 1,1	8,547 ± 1,6	8,084 ± 0,8	7,729 ± 0,3	0,027
L4-L5 (HNP)	Anterior	-	7,740	7,193	6,134	7,156	7,037	6,299	6,835	
	Mid	-	7,070	5,781	5,696	6,015	5,739	5,491	5,692	
	Posterior	-	6,578	4,589	6,718	4,675	4,591	4,594	3,941	
	Mean	-	7,129 ± 0,6	5,855 ± 1,3	6,183 ± 0,5	5,949 ± 1,2	5,789 ± 1,2	5,461 ± 0,8	5,489 ± 1,4	0,020
L5-S1	Anterior	-	10,440	8,636	10,219	10,575	10,465	8,431	7,832	
	Mid	-	8,910	9,398	8,483	9,303	9,724	7,942	8,011	
	Posterior	-	7,615	7,681	7,024	7,766	7,167	7,080	7,345	

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 1	Decade 3 n = 5	Decade 4 n = 5	Decade 5 n = 8	Decade 6 n = 12	Decade 7 n = 3	Decade 8 n = 1	p
	Mean	-	8,988 ± 1,4	8,572 ± 0,9	8,575 ± 1,5	9,215 ± 1,4	9,119 ± 1,7	7,818 ± 0,7	7,729 ± 0,3	0,147

n = total patients

Table 3
Disc height of female samples of HNP patients L4 – L5 (mean ± SD in mm). n = 29

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 1	Decade 3 n = 2	Decade 4 n = 7	Decade 5 n = 11	Decade 6 n = 7	Decade 7 n = 1	Decade 8 n = 0	p
L1-L2	Anterior	-	5,762	8,056	8,363	7,928	8,194	7,636	-	
	Mid	-	5,145	9,062	8,952	8,776	8,387	6,139	-	
	Posterior	-	6,303	7,129	7,001	7,155	6,927	8,970	-	
	Mean	-	5,737 ± 0,6	8,082 ± 1,0	8,105 ± 1,0	7,953 ± 0,8	7,836 ± 0,8	7,582 ± 1,4	-	0,323
L2-L3	Anterior	-	6,633	9,536	9,004	8,980	8,825	8,522	-	
	Mid	-	6,802	8,939	8,904	9,364	8,626	9,251	-	
	Posterior	-	6,802	8,198	7,286	7,539	7,443	8,351	-	
	Mean	-	6,473 ± 0,4	8,891 ± 0,7	8,398 ± 1,0	8,628 ± 1,0	8,298 ± 0,7	8,708 ± 0,5	-	0,228
L3-L4	Anterior	-	7,838	10,201	8,946	9,216	9,532	9,448	-	
	Mid	-	9,011	10,325	9,231	9,825	9,628	10,030	-	
	Posterior	-	7,345	6,807	7,104	6,640	7,002	10,81	-	
	Mean	-	8,065 ± 0,8	9,111 ± 2,0	8,427 ± 1,1	8,560 ± 1,7	8,721 ± 1,5	9,739 ± 0,4	-	0,146
L4-L5 (HNP)	Anterior	-	4,447	6,835	5,276	7,446	7,775	6,835	-	
	Mid	-	5,805	5,692	5,014	7,091	6,017	5,691	-	
	Posterior	-	5,239	3,941	4,905	5,372	4,737	3,941	-	
	Mean	-	5,164 ± 0,7	5,489 ± 1,5	5,065 ± 2,0	6,636 ± 1,1	6,176 ± 1,5	5,489 ± 1,4	-	0,360
L5-S1	Anterior	-	10,30	10,201	9,581	9,951	9,404	10,88	-	
	Mid	-	8,462	10,325	10,090	9,859	9,665	10,030	-	
	Posterior	-	6,943	6,807	7,022	7,558	7,210	9,442	-	
	Mean	-	7,703 ± 1,1	9,111 ± 2,0	8,898 ± 1,6	9,123 ± 1,4	8,759 ± 1,3	9,736 ± 0,4	-	0,090

n = total patients

The distribution of the mean disc height in patients with HNP L4-L5 by sex group and age decade has been described in Tables 2 and 3, to see a clearer picture the data are presented in a graph in Figure 3. Disc height in the male group decreased with age (negative Pearson test) but did not decrease significantly in the female group (positive Pearson test). In this group the height of each disc level between men and women was not significantly different (independent t test p>0.05). L4-L5 disc height has the smallest value compared to other disc levels, according to the location of the HNP (independent t test p=0.017; p <0.05).

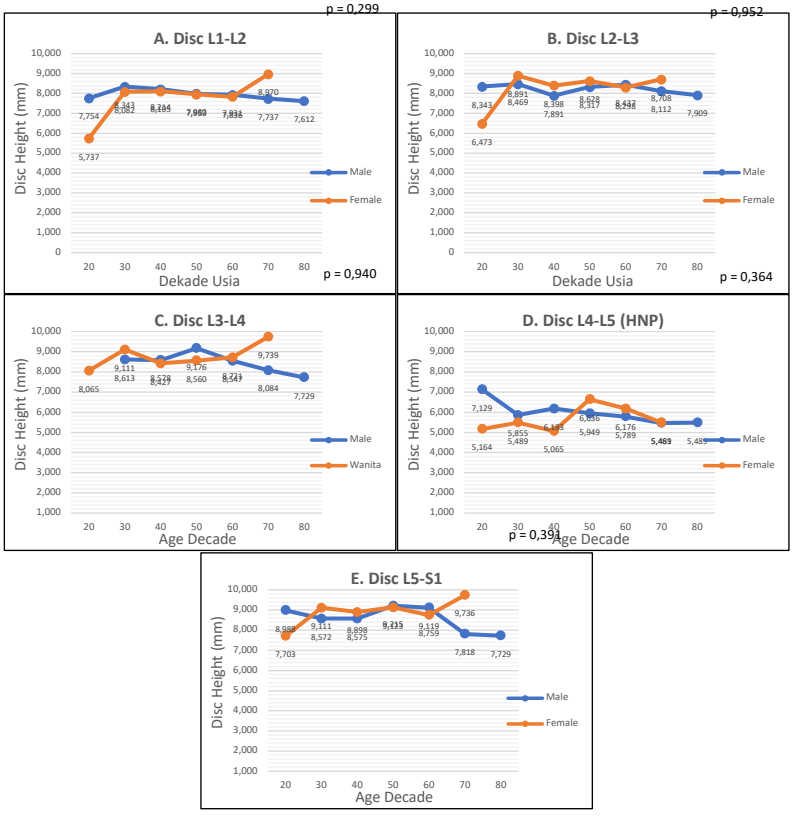


Figure 3. Graph of disc height of HNP L4-5 patients according to gender and age. L1 = lumbar 1, L2 = lumbar 2, L3 = lumbar 3, L4 = lumbar 4, L5 = lumbar 5 and S1 = sacrum 1

The size of the disc height of HNP patients L5-S1

Measurement of disc height in the L5-S1 HNP patient group with a total sample of 13 people, consisting of 9 men and 4 women. In the male group, the mean disc height can be divided into 4 groups according to the decade of age. The mean disc height at L1-L2 levels from anterior, mid and posterior measurements in the male sex group was 8,490 2.1 mm (decade 2), 8.082 0.9 mm (decade 3), 8,533 0.2 mm (decade). 5), and 8.793 0.1 mm (decade 6). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to the decade of age in men can be seen in table 4. In the female group, the mean disc height can be divided into 3 groups according to the decade of age. The mean disc height at L1-L2 levels

from anterior, mid and posterior measurements in the female sex group was 8.468 0.9 mm (decade 4), 8.010 0.8 mm (decade 5), and 7.266 0.5 mm (decade). decade 6). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to age in women can be seen in table 5.

Table 4
Disc height of male samples of HNP patients L5 – S1 (mean ± SD in mm). n = 9

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 1	Decade 3 n = 2	Decade 4 n = 0	Decade 5 n = 4	Decade 6 n = 2	Decade 7 n = 0	Decade 8 n = 0	p
L1-L2	Anterior	-	10,370	8,056	-	8,766	8,916	-	-	
	Mid	-	8,916	9,061	-	8,354	8,838	-	-	
	Posterior	-	6,184	7,129	-	8,478	8,625	-	-	
	Mean	-	8,490 ± 2,1	8,082 ± 0,9	-	8,533 ± 0,2	8,793 ± 0,1	-	-	0,343
L2-L3	Anterior	-	11,020	8,399	-	8,695	8,778	-	-	
	Mid	-	10,340	9,111	-	8,838	9,588	-	-	
	Posterior	-	7,846	8,743	-	8,539	8,462	-	-	
	Mean	-	9,735 ± 1,7	8,751 ± 0,4	-	8,691± 1,5	8,942 ± 0,6	-	-	0,377
L3-L4	Anterior	-	12,510	9,591	-	9,723	9,891	-	-	
	Mid	-	10,80	9,639	-	10,66	9,989	-	-	
	Posterior	-	6,801	8,990	-	10,11	8,647	-	-	
	Mean	-	9,656 ± 3,9	9,407 ± 0,4	-	10,16 ± 0,5	9,509 ± 0,7	-	-	0,749
L4-L5	Anterior	-	11,460	8,447	-	9,150	9,681	-	-	
	Mid	-	11,150	8,944	-	9,626	8,964	-	-	
	Posterior	-	7,291	8,757	-	9,219	8,488	-	-	
	Mean	-	9,967 ± 2,3	8,716 ± 2,5	-	9,332 ± 2,6	9,044 ± 0,6	-	-	0,578
L5-S1 (HNP)	Anterior	-	6,305	5,291	-	6,212	5,989	-	-	
	Mid	-	5,434	3,505	-	5,173	5,715	-	-	
	Posterior	-	5,059	4,615	-	4,532	4,628	-	-	
	Mean	-	5,599 ± 0,6	4,470 ± 0,9	-	5,306 ± 0,8	5,444 ± 0,7	-	-	0,810

Table 5
Disc height of female samples of HNP patients L5 – S1 (mean ± SD in mm). n = 4

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 0	Decade 3 n = 0	Decade 4 n = 1	Decade 5 n = 2	Decade 6 n = 1	Decade 7 n = 0	Decade 8 n = 0	p
L1-L2	Anterior	-	-	-	8,708	8,403	7,833	-	-	
	Mid	-	-	-	9,239	8,604	6,861	-	-	
	Posterior	-	-	-	7,458	7,022	6,861	-	-	
	Mean	-	-	-	8,468 ± 0,9	8,010 ± 0,8	7,266 ± 0,5	-	-	0,087
L2-L3	Anterior	-	-	-	9,777	7,538	7,522	-	-	
	Mid	-	-	-	8,322	8,915	7,251	-	-	
	Posterior	-	-	-	8,557	6,861	7,352	-	-	
	Mean	-	-	-	8,885 ± 0,8	7,771 ± 1,0	7,375 ± 0,1	-	-	0,171
L3-L4	Anterior	-	-	-	8,733	8,105	7,081	-	-	
	Mid	-	-	-	9,357	8,824	7,064	-	-	
	Posterior	-	-	-	8,583	6,253	5,819	-	-	
	Mean	-	-	-	8,891 ± 0,4	7,727 ± 1,3	6,655 ± 0,7	-	-	0,015
L4-L5	Anterior	-	-	-	8,890	8,664	7,082	-	-	
	Mid	-	-	-	8,710	8,533	7,064	-	-	
	Posterior	-	-	-	8,510	6,983	5,819	-	-	
	Mean	-	-	-	8,703 ± 0,2	8,060 ± 0,9	6,655 ± 0,7	-	-	0,135
L5-S1 (HNP)	Anterior	-	-	-	6,259	5,430	5,561	-	-	
	Mid	-	-	-	6,552	4,317	5,128	-	-	
	Posterior	-	-	-	5,668	4,179	3,742	-	-	
	Mean	-	-	-	6,160 ± 0,4	4,642 ± 0,7	4,810 ± 0,9	-	-	0,398

n = total patients

The distribution of mean disc height in patients with HNP L5-S1 by sex group and age decade has been described in Tables 4 and 5, to give a clearer picture, the data are presented in a graph in Figure 4. In the male group, disc height decreased according to age at the L2-L3 and L4-L5 disc levels (negative Pearson test) and in the female group there was a decrease in disc height at all lumbar levels with increasing age (negative Pearson test). In this group the height of each disc level between men and women was significantly different at the L3-L4 disc

level (independent t test p<0.05). L4-L5 disc height has the smallest value compared to other disc levels, according to the location of the HNP (independent t test p=0.001; p <0.05).

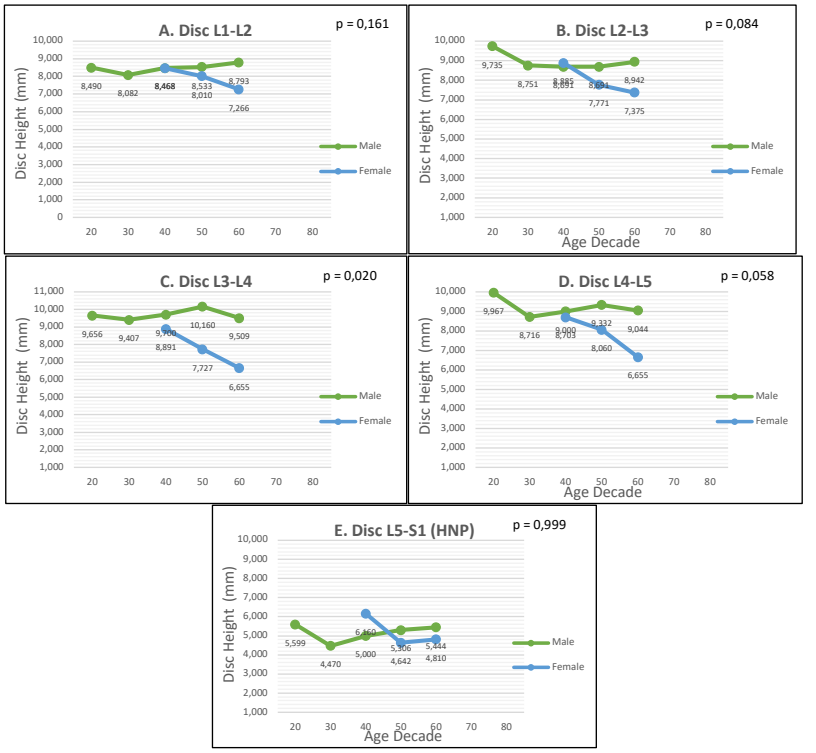


Figure 4. Graph of disc height of L5-S1 HNP patients according to gender and age.

The size of the disc height of HNP patients L4-L5+L5-S1

Measurement of disc height in the HNP patient group at two lumbar levels at once, namely at the L4-L5 and L5-S1 levels with a total sample of 23 people, consisting of 13 men and 10 women. In the male group, the mean disc height can be divided into 5 groups according to the decade of age. The mean disc height at L1-L2 levels from anterior, mid and posterior measurements in the male sex group was 8.564 0.4 mm (decade 2), 8.691 0.7 mm (decade 5), 8.095 0.7 mm (decade). 6), 8.191 0.9 mm (decade 7), and 8.268 1.2 mm (decade 8). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to the decade of age in men can be seen in table 6. In the female group, the mean disc height can be divided into 5 groups according to the decade of age. The mean disc height at L1-L2 levels from anterior, mid and posterior measurements in the female sex group was 7.997 0.1mm (decade 3), 8.108 0.6 mm (decade 4), 8.168 0.5 mm (decade 5), 7.933 1.0 mm (decade 6) and 7.755 0.6 mm (decade 7). The mean value of disc height at the next level L2-L3, L3-L4, L4-L5 and L5-S1 according to age in women can be seen in table 7.

Table 6
Disc height of male samples of HNP patients L4-L5 + L5–S1. (mean ± SD in mm).
n = 13

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 1	Decade 3 n = 0	Decade 4 n = 0	Decade 5 n = 4	Decade 6 n = 5	Decade 7 n = 2	Decade 8 n = 1	p
L1-L2	Anterior	-	8,636	-	-	8,896	8,709	8,971	8,833	
	Mid	-	8,139	-	-	9,313	8,278	8,377	9,101	
	Posterior	-	8,917	-	-	7,864	7,298	7,226	6,869	
	Mean	-	8,564 ± 0,4	-	-	8,691 ± 0,7	8,095 ± 0,7	8,191 ± 0,9	8,268 ± 1,2	0,245
L2-L3	Anterior	-	10,010	-	-	9,422	9,264	8,178	8,522	
	Mid	-	8,019	-	-	8,773	9,222	8,027	8,251	
	Posterior	-	8,188	-	-	8,175	8,313	7,293	7,351	
	Mean	-	8,739 ± 1,1	-	-	8,790 ± 0,6	8,933 ± 0,5	7,833 ± 0,5	8,041 ± 0,6	0,024
L3-L4	Anterior	-	9,441	-	-	10,189	9,536	7,568	8,041	
	Mid	-	10,03	-	-	9,032	9,870	8,425	8,591	
	Posterior	-	10,88	-	-	8,059	7,846	7,956	7,977	
	Mean	-	10,11 ± 0,7	-	-	9,094 ± 1,0	9,084 ± 1,0	7,983 ± 0,4	8,203 ± 0,3	0,016
L4-L5 (HNP)	Anterior	-	6,835	-	-	5,833	7,563	6,230	5,835	
	Mid	-	5,691	-	-	5,406	5,645	6,104	5,691	
	Posterior	-	3,941	-	-	5,367	4,354	4,582	3,941	
	Mean	-	5,489 ± 1,4	-	-	5,535 ± 0,2	5,854 ± 1,6	5,639 ± 0,9	5,156 ± 1,0	0,746
L5-S1 (HNP)	Anterior	-	6,505	-	-	6,899	6,492	5,835	6,505	
	Mid	-	6,120	-	-	6,014	5,708	5,835	5,120	
	Posterior	-	6,193	-	-	5,938	4,885	5,429	5,193	
	Mean	-	6,273 ± 0,2	-	-	6,283 ± 0,5	5,695 ± 0,8	5,715 ± 0,2	5,606 ± 0,8	0,068

Table 7
Disc height of female samples of HNP patients L4-L5 + L5–S1. (mean ± SD in mm). n = 10

Disc Level	Location	Decade 1 n = 0	Decade 2 n = 0	Decade 3 n = 2	Decade 4 n = 1	Decade 5 n = 5	Decade 6 n = 1	Decade 7 n = 1	Decade 8 n = 0	P
L1-L2	Anterior	-	-	8,033	8,300	8,709	8,833	7,681	-	
	Mid	-	-	7,948	8,300	7,910	8,104	8,379	-	
	Posterior	-	-	8,012	7,444	7,885	6,861	7,204	-	
	Mean	-	-	7,997 ± 0,1	8,108 ± 0,6	8,168 ± 0,5	7,933 ± 1,0	7,755 ± 0,6	-	0,239
L2-L3	Anterior	-	-	10,800	8,741	9,255	8,080	8,271	-	
	Mid	-	-	8,901	7,899	8,786	8,909	7,976	-	
	Posterior	-	-	7,262	6,615	7,687	7,262	8,134	-	
	Mean	-	-	8,988 ± 1,7	7,752 ± 1,0	8,576 ± 0,8	8,084 ± 0,8	8,127 ± 0,1	-	0,439
L3-L4	Anterior	-	-	8,910	9,893	8,969	7,838	8,591	-	
	Mid	-	-	9,331	8,490	8,412	8,008	7,794	-	
	Posterior	-	-	7,625	7,322	7,075	7,345	7,794	-	
	Mean	-	-	8,622 ± 0,8	8,568 ± 1,2	8,152 ± 1,0	7,730 ± 0,3	7,829 ± 0,7	-	0,020
L4-L5 (HNP)	Anterior	-	-	6,501	7,177	6,523	6,835	4,161	-	
	Mid	-	-	6,120	5,266	5,785	5,691	4,692	-	
	Posterior	-	-	6,193	5,188	4,484	3,941	4,541	-	
	Mean	-	-	6,271 ± 0,2	5,877 ± 1,1	5,597 ± 1,0	5,489 ± 1,4	4,465 ± 0,3	-	0,017
L5-S1 (HNP)	Anterior	-	-	6,061	6041	6,232	5,505	5,835	-	
	Mid	-	-	5,602	5033	4,477	5,120	5,691	-	
	Posterior	-	-	4,778	5,023	4,765	5,193	3,941	-	
	Mean	-	-	5,480 ± 0,6	5,366 ± 0,5	5,158 ± 0,9	5,273 ± 0,2	5,156 ± 1,0	-	0,017

The distribution of the mean disc height in the HNP patient group at two disc levels L4-L5 and L5-S1 by gender and age decade has been described in Tables 6 and 7, to provide a clearer picture the data are presented in a graph in Figure 5. The height of the disc in the male and female groups decreased with increasing age (negative Pearson test). In this group the height of each disc level between men and women was significantly different at the L1-L2 and L5-S1 disc levels (independent t test $p<0.05$). L4-L5 disc height has the smallest value compared to other disc levels, according to the location of the HNP (independent t test $p=0.001$; $p <0.05$).

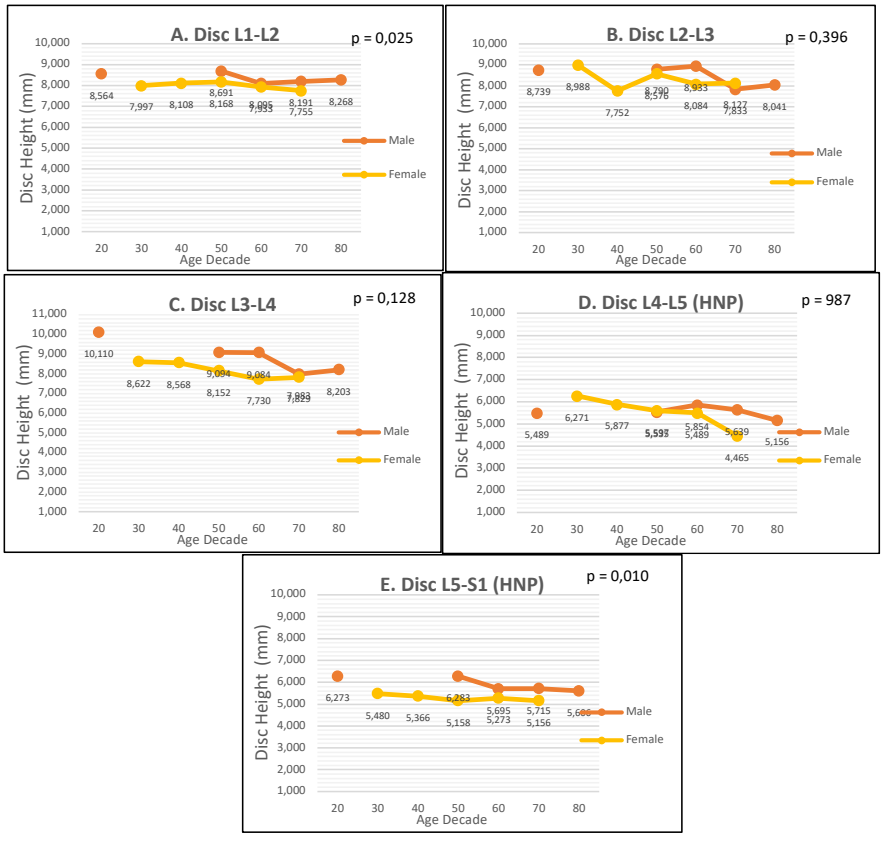


Figure 5. Graph of disc height of patients with HNP L4-L5 + L5-S1 according to gender and age

Average disc height at each level

The mean disc height for each level was calculated for each patient group. In the L4-L5 HNP patient group, the mean disc height in men was 7.898±0.3 mm and in women 7.549±0.9 mm for the L1-L2 disc level, 8.211±0.2 mm in men and 8.233±0,7 mm in women for the L2-L3 disc level, 8.739±0.9 mm in men and 8,770±0.6 mm in women for the L3-L4 disc level, which is 5.979±0.6 mm in men and 5,670±0,6 mm in women for the L4-L5 disc level, 8.574±0.6 mm in men and 8,888±0.7 mm in women for the L5-S1 disc level. The overall data on the mean disc height for each lumbar level in each patient group is distinguished between

men and women, the distribution and pattern can be seen in table 8. Statistical independent t test on the difference in mean disc height between men and women in all study samples did not show a significant difference (p>0.005). The mean disc height with HNP was lower than the other lumbar disc height without HNP. In the L4-L5 HNP patient group, the L4-L5 disc height was statistically significantly lower than the L3-L4 disc height with independent t test p = 0.003 (p<0.005) and when compared with high level L5-S1 discs it was statistically significant (p<0.005). In the other group of patients with L5-S1 and L4-L5+L5-S1 HNP, the disc height was statistically significantly lower than the disc level without HNP.

Table 8
Total mean lumbar disc height by level and sex. Mean ± SD in millimetre

Disc Level	Sex	Patient Groups		
		HNP L4-L5 n = 64	HNP L5-S1 n = 13	HNP (L4-L5 + L5-S1) n = 23
L1-L2	Male	7,898 ± 0,3	8,474 ± 0,3	8,362 ± 0,2
	Female	7,549 ± 0,9	7,915 ± 0,6	7,992 ± 0,2
L2-L3	Male	8,211 ± 0,2	9,030 ± 0,5	8,467 ± 0,5
	Female	8,233 ± 0,7	8,011 ± 0,8	8,305 ± 0,5
L3-L4	Male	8,739 ± 0,9	9,684 ± 0,3	8,896 ± 0,8
	Female	8,770 ± 0,6	7,758 ± 1,1	8,180 ±0,4
L4-L5	Male	5,979 ± 0,6	9,306 ± 0,5	5,535 ± 0,2
	Female	5,670 ± 0,6	7,806 ± 1,0	5,540 ± 0,7
L5-S1	Male	8,574 ± 0,6	5,205 ± 0,5	5,914 ± 0,3
	Female	8,888 +0,7	5,204 ± 0,8	5,286 ± 0,1

n =number of patients

The graph on the following page is based on disc height calculation data at each level of the lumbar disc according to the grouping of HNP patients to make it easier to understand. The graphic presentation also shows the low height of discs with HNP compared to normal discs, as shown in Figures 6, 7 and 8 below.

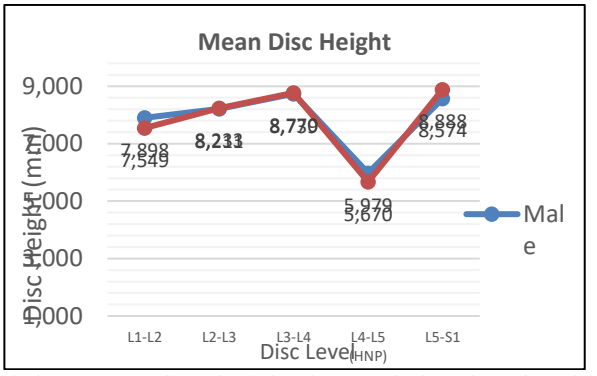


Figure 6. Graph of the mean disc height for each lumbar level in the L4-L5 HNP patient group

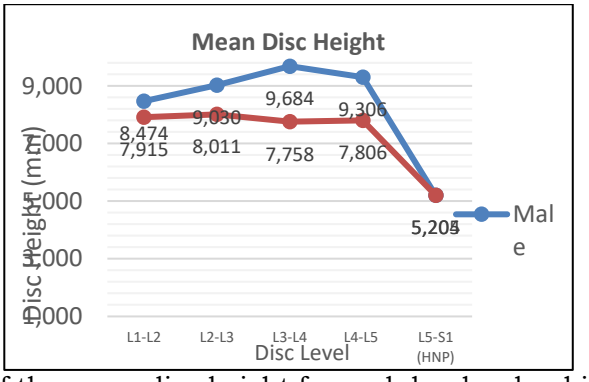


Figure 7. Graph of the mean disc height for each lumbar level in the L5-S1 HNP patient group

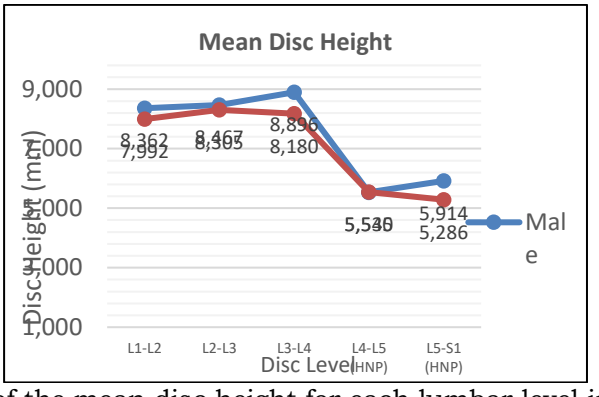


Figure 8. Graph of the mean disc height for each lumbar level in the L5-S1 HNP patient group

Disc Degenerative Degrees Based on Pfirrmann Grading

The interpretation of the degree of disc degeneration is then assessed based on the grade and lumbar level of each disc. Pfirrmann grade 1 is the grade with the least amount of 20 discs found out of a total of 500 discs, while grade III is the most common degenerative disc degree with 201 discs out of a total of 500 discs.

The most common degrees of degeneration IV and V were found at the disc level with HNP and were statistically significant compared to the disc level without HNP ($p<0.005$). The distribution of the Pfirrmann degree frequency for each disc along with the mean disc height can be seen in figure 9.

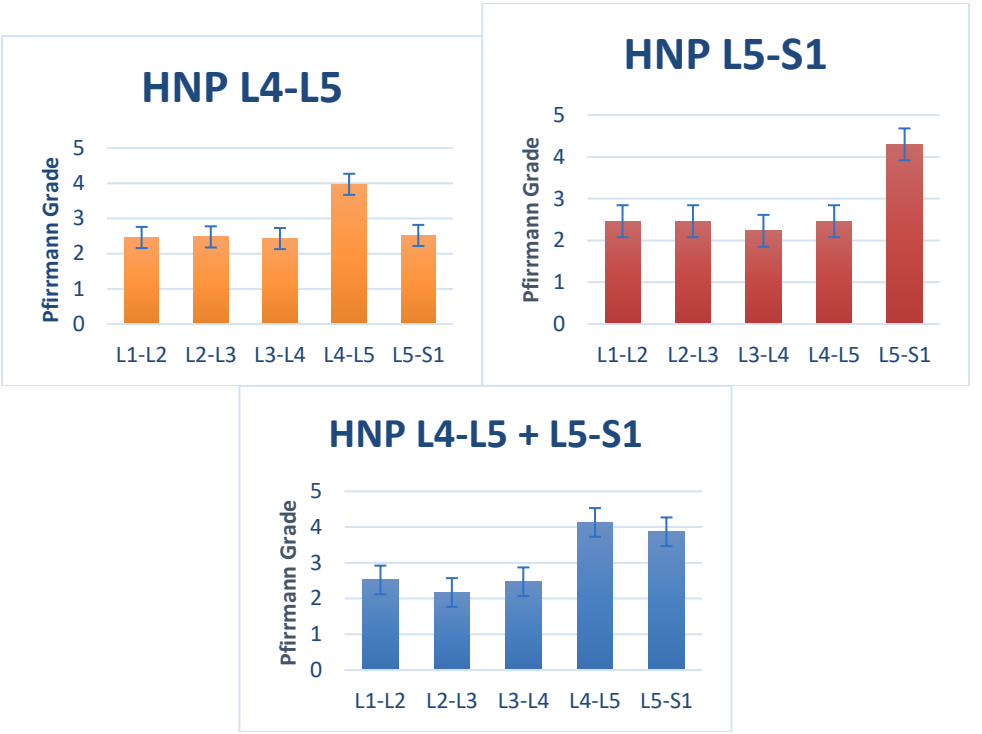
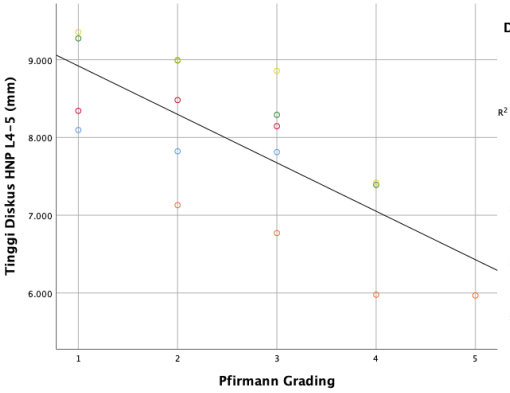


Figure 9. Pfirrmann grade distribution graph on each lumbar disc

Relationship Between Disc Height and Degree of Degenerative

The results of the Pearson test in the three groups of patients, namely in the HNP L4-L5, HNP L5-S1 and HNP patient groups at both disc levels showed an inverse relationship between disc height and Pfirrmann's degenerative degree which was statistically significant, with values in the HNP L4-L5 group Pearson correlation $r = -0.729$ ($p<0.001$), in the HNP L5-S1 group Pearson correlation $r = -0.876$ ($p<0.001$) and in the HNP L4-L4 + L5+S1 group Pearson correlation $r = -0.970$ ($p <0.001$). The graph of the relationship between disc height and degenerative degrees with Pearson's test calculations can be seen in Figures 10, 11 and 12. The result of the Pearson test which is negative (-) with $p<0.001$, indicates an inverse relationship between the two variables which is statistically significant. The values obtained in the three groups of patients showed the same results and were broad and supported the hypothesis of this study.

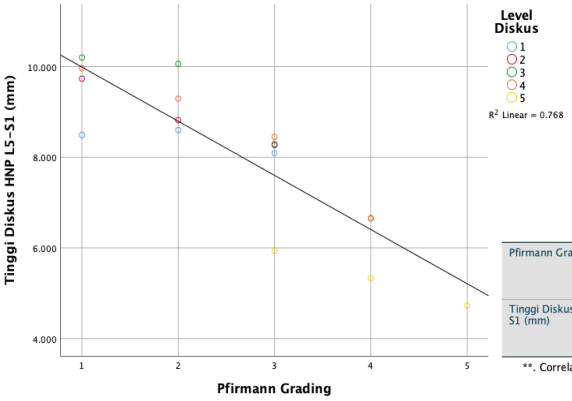


Correlations

		Pfirmann Grading	Tinggi Diskus HNP L4-5 (mm)
Pfirmann Grading	Pearson Correlation	1	-.729**
	Sig. (2-tailed)		.001
	N	25	18
Tinggi Diskus HNP L4-5 (mm)	Pearson Correlation	-.729**	1
	Sig. (2-tailed)	.001	
	N	18	18

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

Figure 10. Graph of the relationship between disc height and degree of disc degeneration in HNP L4-L5. Significantly inverse relationship with Pfirrmann classification (Pearson correlation r = -0.729, p<0.001)

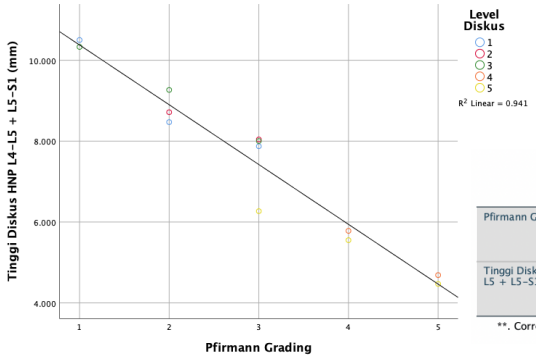


Correlations

		Pfirmann Grading	Tinggi Diskus HNP L5-S1 (mm)
Pfirmann Grading	Pearson Correlation	1	-.876**
	Sig. (2-tailed)		.000
	N	25	17
Tinggi Diskus HNP L5-S1 (mm)	Pearson Correlation	-.876**	1
	Sig. (2-tailed)	.000	
	N	17	17

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

Figure 11. Graph of the relationship between disc height and degree of disc degeneration in L4-L5 HNP. Significantly inverse relationship with Pfirrmann classification (Pearson correlation r = -0.876, p<0.001)



		Pfirmann Grading	Tinggi Diskus HNP L4-L5 + L5-S1 (mm)
Pfirmann Grading	Pearson Correlation	1	-.970**
	Sig. (2-tailed)		.000
	N	25	13
Tinggi Diskus HNP L4-L5 + L5-S1 (mm)	Pearson Correlation	-.970**	1
	Sig. (2-tailed)	.000	
	N	13	13

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

Figure 12. Graph of the relationship between disc height and degree of disc degeneration in HNP L4-L5. Significantly inverse relationship with Pfirrmann classification (Pearson correlation r = -0.970, p<0.001)

Discussion

The general definition of disc degenerative disease is based on the appearance of the intervertebral disc on MRI, because loss of disc signal on T2-weighted images reflects decreased proteoglycan and disc water content. Based on the degree of degeneration, structural changes and loss of disc height can be visualized on MRI. Based on proton density, moisture content and chemical environment, MRI can depict the hydration and morphology of the disc. Analysis of the biochemical changes in the disc has shown that MRI reflects the proteoglycan content of the nucleus pulposus. The brightness of the nucleus has been shown to be directly correlated with the concentration of proteoglycans. Disc signal characteristics on T2-weighted MRI may reflect changes caused by aging or degeneration. Disc degeneration is seen as reduced signaling of the nucleus and annulus fibers. In more severe disc degeneration, there is no demarcation between the inner and outer fibers of the annulus, and disc height decreases. The loss of MRI signal intensity in the early phase of degeneration is not always accompanied by disc height, although in the process of development of subsequent degeneration in some literature shows a significant loss of disc height. Variations in hydration state and disc composition can be detected noninvasively by quantitative MRI with good accuracy. (da Costa et al., 2020; Kreiner et al., 2020; Roberts et al., 2021; Rosyid, Yamin and Puspitasari, 2019; Widmer et al., 2021).

The lumbar spine is the most biomechanically stressed part of the spine due to load-bearing. The incidence of lower lumbar degeneration (L4-L5, L5-S1) is 74.6% greater than degeneration at the upper lumbar level (25.4%), what is interesting is the presence of degenerative events at the upper lumbar level where mechanical loads are not too large to be supported, this is related to the influence of the patient's age. This study provides geometric data from the lumbar disc obtained through MRI both on normal lumbar discs and lumbar discs with HNP, with the hope of providing adequate data, especially regarding disc height based on gender and age demographics. The use of Horos software allows the evaluation of MRI with DICOM format, so that it can provide a good morphology and condition of the condition of the lumbar disc compared to other imaging. The MRI T2 sequence is used as an option in detecting disc degeneration because it is a sensitive sequence in detecting early stage conditions of disc degeneration, according to the findings of signal intensity which has a close relationship in Pfirrmann grading. (Ogon et al., 2021; Wu et al., 2022; Zheng et al., 2022)

The results of the MRI scan produced comprehensive disc morphometric data for both male and female patient samples, measurements were made at all levels of the lumbar disc so that significant differences and relationships would be seen in each disc representing the population condition in both normal and lumbar discs. with HNP. This study is the first study to accurately provide individual disc height data according to the demographics of the sample followed by the relationship between disc height that can be measured and the degree of Pfirrmann degeneration in patients with lower lumbar disc HNP, which until now has been used as a qualitative measure of the condition. discus. The measurement is done blinded, that is, the measurer does not know the characteristics of the sample in the form of age, gender, occupation and pre-operative diagnosis, so it is hoped that the results will be objective. The disc height data in this study is also

expected to accommodate data needs to assist further research, including the manufacture of disc prostheses. (Bach et al., 2019; Machino et al., 2021; Virk et al., 2021)

In this study, it was found that the distribution of the incidence of HNP which is one of the signs of disc degenerative events, especially increases with increasing age. In the male sample, the incidence of HNP was found in the sixth decade as many as 19 patients and in women in the fifth decade as many as 18 patients. This is in accordance with several previous studies that explain the increasing prevalence of disc degeneration related to age, with data on the prevalence of LBP increasing by 38% each year and in the overall human life span the prevalence increases by 80%. The sample of this study consisted of men and women whose numbers did not differ significantly. The high incidence of HNP in women has been studied previously, although the exact cause is unknown, in women it is possible because the process of osteoporosis and pregnancy may be the cause of women having a higher prevalence of LBP than men. Another factor that causes an increase in LBP is socioeconomic life. Low economic life, lack of access to health facilities and obesity are things related to the incidence of LBP, but in this study the demographic data could not be found in medical records which would later be input for the future. (de Souza et al., 2019; Fatoye, Gebrye and Odeyemi, 2019; Serranheira et al., 2020)

The disc height data found in this study has several characteristics that were also found in previous studies, including an increase in disc height which is positively correlated with the spinal level where the lower the lumbar level, the greater the disc height as shown in Figures 5.4, 5.5, and 5.6. This is in accordance with the research of Pfirrmann et al. which explains that the increase in lower lumbar disc height is associated with heavier disc function in bearing weight. The disc height also decreased at the level of the disc with HNP compared to the disc at other normal lumbar levels, this was attributed to the expulsion of disc material that supports the volume and height structure. The disc height measured at the three anterior, mid and posterior points showed a tendency to enlarge the disc at the anterior point, this explains the lordotic condition found at the lumbar level. In this study, disc height tends to decrease according to decades of age, this is directly related to the incidence of disc degenerative at the age above 50 years and is also supported by several studies where disc height decreases with age. The disc height in the male and female samples did not show a significant difference ($p>0.01$), but it cannot be concluded because several other factors have not been identified in this study due to data limitations such as BMI and muscle mass conditions. (Pfirrmann et al., 2001; Bach et al., 2019; Al Qaraghli and De Jesus, 2022)

This study used the Pfirrmann grading system, a valid and reliable way to assess intervertebral disc degeneration from MRI, to classify disc degeneration. The descriptors used to assess disc height in the Pfirrmann scoring system include normal (grades 1 and 2), normal to slightly decreased (grade 3), normal to severely decreased (grade 4) and collapsed (grade 5). The Pfrimann degree does not directly provide an image of disc height that defines normal disc height, because it is influenced by variations between individuals. This study assessed intervertebral disc height as a continuous measure and showed that for each increase in the

severity of disc degeneration, there was a mean disc narrowing of 0.43 mm to 1.44 mm at various spinal lumbosacral disc levels, independent of age, sex. , BMI and smoking history. (Pfirrmann et al., 2001; Cao, Guo and Wan, 2020; Xu, Yin and Mo, 2020; Teixeira et al., 2021)

In the analysis of the findings from MRI, it showed that compared to the degrees of disc degenerative at L1-L2, L2-L3 and L3-L4, the levels of the L4-L5 and L5-S1 discs showed more severe disc degeneration, with the highest frequency of Pfirrmann grades being grades IV and V, it can be associated with greater mechanical stress to withstand the workload. In this study, the highest distribution of degenerative degrees in healthy non-HNP discs was grade III, as many as 201 discs (40.2%) of the total 500 discs studied, this is related to the age of the sample with an average age of 54.4 years where in the literature It is said that disc degeneration is directly proportional to decades of age. In the disc group with HNP, grade IV was the highest grade of 106 discs (21.2%) out of a total of 500 discs, this was related and specific only to discs with HNP. The fragility of the degenerated disc structure can cause tears in the annulus which can make herniation of the nucleus pulposus structure. (Cao, Guo and Wan, 2020; Roberts et al., 2021)

This study proves that there is an inverse relationship between disc height and the degree of degeneration. In the Pearson statistical test it was found that the lower the height of the intervertebral disc, the higher the degree of degeneration and vice versa. The results of the Pearson test in the three groups of patients, namely in the HNP L4-L5, HNP L5-S1 and HNP patient groups at both disc levels showed an inverse relationship between disc height and Pfirrmann's degenerative degree which was statistically significant, with values in the L4 HNP group. -L5 Pearson correlation $r = -0.729$ ($p<0.001$), in the HNP group L5-S1 Pearson correlation $r = -0.876$ ($p<0.001$) and in the HNP group L4-L4 + L5+S1 Pearson correlation $r = -0.970$ ($p <0.001$). The average disc height at Pfirrmann grade I was 9.037 0.7 mm, grade II was 8.599 0.6 mm, grade III was 7.792 0.8 mm, grade IV was 6.345 0.8 mm, and grade IV was 6.345 0.8 mm. V of 4.963 0.7 mm. In the study by Dragsbæk et al. in 2020 suggested that a decrease in disc height was associated with an increase in low back pain.

Data regarding the relationship between disc height and degenerative degrees can help clinicians in the field to find out early about the risk of degenerative conditions according to simple imaging such as x-rays that are carried out if MRI facilities are not yet available, this can make a preventive step to prevent worsening of symptoms by How to educate patients about these risk factors. (Sher et al., 2019; Dragsbæk et al., 2020; George et al., 2021). The limitations of the current study are related to preoperative data on risk factors that have not been recorded in the patient's medical record, including data on height, weight, body mass index, smoking and occupational history that can help explain the prevalence of LBP. Discus height is also influenced by ethnicity and race so that it is necessary to pay attention to its implementation in helping to make a synthesis nucleus that is in accordance with the needs of the community.

Conclusion

The average height of the intervertebral disc in lumbar degenerative disease is 8.162 0.2 mm disc level L1-L2; of 8.623 0.3 mm for the L2-L3 disc level; of 8.823 0.3 mm for the L3-L4 disc level; of 5.830 0.3 mm for the L4-L5 disc level and 5,388 0.3 mm for the L5-S1 disc level. The average disc height at Pfirrmann grade I was 9.037 0.7 mm, grade II was 8.599 0.6 mm, grade III was 7.792 0.8 mm, grade IV was 6.345 0.8 mm, and grade IV was 6.345 0.8 mm. V of 4.963 0.7 mm. The results of the Pearson test in the three groups of patients, namely in the HNP L4-L5, HNP L5-S1 and HNP patient groups at both disc levels showed an inverse relationship between disc height and Pfirrmann's degenerative degree which was statistically significant, with values in the L4 HNP group. -L5 Pearson correlation $r = -0.729$ ($p<0.001$), in the HNP group L5-S1 Pearson correlation $r = -0.876$ ($p<0.001$) and in the HNP group L4-L4 + L5+S1 Pearson correlation $r = -0.970$ ($p <0.001$).

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