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Is There Any Association between the Severity of Disc Degeneration and Low Back Pain?*

Existe alguma associação entre gravidade de degeneração discal e dor lombar?

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Abstract

Objective To access the possibility that higher degrees of disc degeneration lead to higher levels of pain and dysfunction.

Methods Magnetic resonance imaging (MRI) scans of 85 patients with low back pain lasting for more than 12 weeks were evaluated, and the degree of disc degeneration was quantified according to the Pfirrmann grading system. The Pfirrmann degree in each disc space from L1-L2 to L5-S1, the maximum degree of Pfirrmann (Pfirrmann-max) between the lumbar discs, and the sum of Pfirrmann (Pfirrmann-sum) degrees were correlated (through the Spearman test) with the Oswestry Disability Index (ODI) and the Visual Analogical Scale (VAS) for pain.

Results In total, 87% of the patients had moderate to severe lumbar disc degeneration measured by Pfirrmann-max, and the most degenerated discs were L4-L5 and L5-S1. There was a week to moderate correlation regarding the Pfirrmann-max ($r = 0{,}330$; $p = 0.002$) and the Pfirrmann-sum ($r = 0{,}266$; $p = 0{,}037$) and the ODI, and the Pfirrmann scores in L1-L2 were correlated with the ODI and the VAS.

Conclusion Patients with chronic idiopathic low back pain frequently have moderate to severe lumbar disc degeneration, which has a negative impact on the quality of life of the patients. Low degrees of degeneration in L1-L2 might be related with higher degrees of pain and of functional disability.

Keywords
- spine
- quality of life
- magnetic resonance imaging
- low back pain
- intervertebral disc

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Resumo

Objetivo Avaliar a possibilidade de maiores graus de degeneração discal levarem a maiores dor e disfunção.

Métodos Exames de imagem por ressonância magnética (IRM) de 85 pacientes com lombalgia idiopática por mais de 12 semanas foram avaliados, sendo quantificado o grau de degeneração discal de acordo com a escala de Pfirrmann. O grau de Pfirrmann em cada espaço discal de L1-L2 a L5-S1, o grau máximo de Pfirrmann (Pfirrmann-max) entre os discos lombares, e a soma dos graus de Pfirrmann (Pfirrmann-soma) foram correlacionados (por meio do teste de Spearman) com o Índice de Incapacidade de Oswestry (IIO) e a escala visual analógica (EVA) de dor.

Resultados No total, 87% dos pacientes tinha degeneração discal moderada ou acentuada medida pelo Pfirrmann-max, sendo L4-L5 e L5-S1 os discos mais degenerados. Houve uma correlação de fraca a moderada entre o Pfirrmann-max ($r = 0{,}330$; $p = 0.002$) e a Pfirrmann-soma ($r = 0{,}266$; $p = 0{,}037$) e o IIO, e entre o grau de Pfirrmann em L1-L2 e o IIO e a EVA.

Conclusão A degeneração discal lombar moderada ou acentuada é frequente em indivíduos com lombalgia crônica idiopática, e tem um impacto negativo na qualidade de vida dos pacientes. Pequenos graus de degeneração discal em L1-L2 podem determinar maior grau de dor e maior incapacidade funcional.

Palavras-chave

- coluna vertebral
- qualidade de vida
- imagem por ressonância magnética
- lombalgia
- disco intervertebral

Introduction

Low back pain is a very prevalent symptom that can affect 40% to 65% of the population, and it is estimated that 70% to 85% of people will have at least one episode of low back pain throughout their lives.[1–3] Acute or recurrent low back pain is the second most frequent complaint in medical offices, and the most frequent cause of activity limitation in individuals under 45 years of age in the United States.[3] In addition to its economic and social impacts, chronic low back pain also impacts the quality of life of affected patients.[2]

Most patients (60% to 70%) with low back pain recover from the symptoms within 6 weeks, but recovery is slower in patients with associated sciatalgia.[3] In about 10% of the patients, the symptoms persist for more than 12 weeks, which characterizes chronic low back pain.[2] In such cases, the degree of recovery is even slower and uncertain.[3]

The etiology of low back pain is complex and multifactorial. Certain causes, such as trauma, fracture, muscle stretching, bone or paravertebral injury due to neoplasms, infections, ankylosing spondylitis, protrusion or disc herniation with root involvement etc., are recognizable and specific to low back pain.[4,5] However, in up to 85% of the cases of low back pain, it is not possible to diagnose a cause; these cases and they are classified as idiopathic or non-specific low back pain.[6] In tertiary centers, the percentage of cases of idiopathic low back pain is lower (50%).[7] The American College of Physicians and the American Society of Pain recommend that low back pain be classified into three categories: 1) non-specific or idiopathic low back pain; 2) low back pain potentially associated with root compression or stenosis of the vertebral canal; and 3) low back pain associated with specific causes.[8] There is consensus among experts that most idiopathic low back pain does not require complementary investigation by imaging methods, due to its high frequency and high recovery rate with conventional therapy. However, the persistence of low back pain for more than six weeks is a warning sign that deserves further investigation.[9]

More recently, certain anatomic structures have been considered as probable causes for low back pain.[10] These cases also have multifactorial etiology, with possible origin in discal or ligament elements, articular facets, and paraspinal muscles.[10] The process of disc degeneration is associated with loss of hydration and of proteoglycans of the pulpnucleus, with progressive biochemical alterations, which, in more advanced stages, are associated with loss of cell matrix integrity, loss of support and degeneration of the fibrous annuity, culminating in changes in disc morphology (such as disc bulging and fissures), reduction in height, loss of biomechanical support, and disc collapse.[11] It is believed that degenerative discopathy has an etiological role in idiopathic low back pain or discogenic pain,[12] either by accentuating the instability of the vertebral segments, which overloads the other support structures,[13] or by inflammation or the formation of vascularized granulomatous tissue around the fibrous nullus, stimulating nociceptive fibers.[14,15]

There is still no consensus regarding the diagnostic definition of discogenic low back pain, the main associated factors, and the most appropriate diagnostic protocols to access it.[10] Many studies[16–18] include, in the investigation of degenerative discopathy, measurements of vertebral listeses and misalignments, disc bulging, osteophytes and signal alterations of vertebral end plates, and signs of ligament and facet disease, hindering the investigation of the relationship between low back pain and isolated signs of disc signal and height alteration. In the present

study, we determined the degree of disc degeneration in a sample of patients with chronic low back pain in a tertiary hospital, using the Pfirrmann disc degeneration scale[19] evaluated on magnetic resonance imaging (MRI) scans, analyzing the association between these measures and scales of quality of life and pain.

Methods

The present work is an observational, cross-sectional study that included patients with chronic low back pain refractory to clinical treatment, followed up at the orthopedic outpatient clinic of a tertiary hospital between January 2017 and July 2019. The study was approved by the Ethics Committee on Research on Human Beings (under CAAE 90700618.8.0000.0062). All participants signed the free and informed consent form (FICF).

The patients included had low back pain for more than 12 weeks, with no age limitation. Patients with other central or peripheral neuropathies, previous cerebral and spinal surgeries, vascular diseases, or other diseases of the spine that cause low back pain (such as vertebral fractures, spondylolisthesis, tumors, stenosis of the lumbar canal, or discitis), pelvis or hip diseases, and rheumatologic diseases were excluded. To be included, the patient needed to have a recent MRI exam.

Clinical data

Clinical data and data from quality of life and pain questionnaires were collected by personal and face-to-face interviews. Demographic data (gender, age, weight) were collected. Quality of life and subjective disability were assessed by the Brazilian version of the Oswestry Disability Index (ODI),[20] which contains ten questions pertaining to pain and functional ability. Each question has six alternatives, to which points from zero to five are attributed from the lowest to the highest degree of injury respectively. The points are added and then divided by the number of questions answered by the patient and multiplied by 100, and the result is the percentage of disability related to low back pain. The ODI can be classified as: minimal disability (0% to 20%); moderate disability (21% to 40%); severe disability (41% to 60%); crippling back pain (61% to 80%), and bed-bound individual (81% to 100%).

Low back pain was classified by the visual analog scale (VAS) for pain,[21] in which the patients classify their pain from zero (absence of pain) to ten (worst pain imaginable) based on images that correspond to the sensation of pain. It is of quick application and easy to understand by the patients.

Evaluation of magnetic resonance imaging

The MRI scans were evaluated by two orthopedists with experience in spinal pathologies. Each intervertebral disc of the lumbar spine was analyzed individually, being defined by the letter L and the number corresponding to the anatomical position occupied by the cranial vertebra and caudal vertebra, and classified from L1-L2 to L5-S1. For standardization purposes, whenever characteristics of transition vertebrae or more than 5 lumbar vertebrae were found, the last segment included in the study was L5-S1.

T2-weighted MRI scans were analyzed in the sagittal plane, and the degree of degeneration was classified into 5 levels according to Pfirrmann et al.[19] (►**Figure 1**).

Statistical analysis

Descriptive statistics were presented as absolute and relative frequencies, means and standard deviations, medians, and interquartile ranges, when appropriate. To assess the degree of functional disability, the ODI was recoded in 5 degrees: 1) minimal disability (0% to 20%); 2) moderate disability (21% to 40%); 3) severe disability (41% to 60%); 4) crippling back pain (61% to 80%); and 5) bed-bound individual (81% to 100%).

The Kruskal-Wallis test was used to compare ODI and VAS scores regarding groups of patients with different degrees of maximum Pfirrmann degeneration.

For the evaluation of the correlations of the degree of disc degeneration and the ODI and VAS, we used the Spearman nonparametric test, because disc degeneration (Pfirrmann degree) is a categorical variable. The Spearman coefficient was evaluated regarding the maximum degree of Pfirrmann (Pfirrmann-max) found in the discs of each individual. To evaluate the Spearman coefficient in each disc segment, the Pfirmann variable was recoded into 3 levels: level 1–no significant degeneration or mild degeneration (Pfirrmann 1 and 2); level 2–moderate degeneration (Pfirrmann 3); and level 3–marked degeneration (Pfirrmann 4 and 5). The modified Pfirmann values were added (Pfirrmann-sum), and the resulting variable was correlated with the ODI

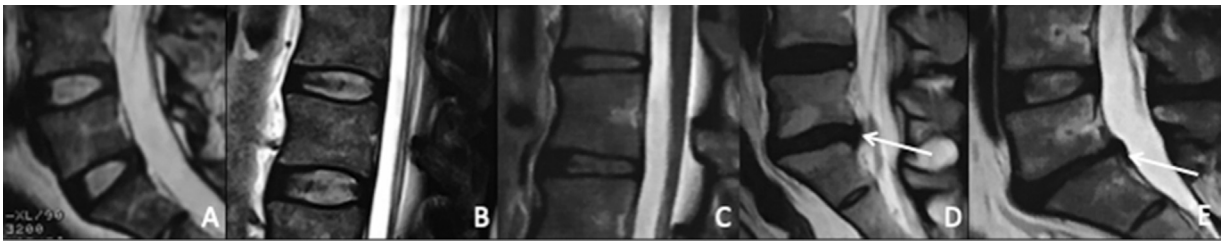

Fig. 1 Pfirrmann classification of disc degeneration exemplified in magnetic resonance imaging scans of individuals from the group evaluated in the study. (**A**) degree 1 of Pfirrmann: hyperintense and homogeneous nucleus pulposus and preserved disc height; (**B**) degree 2: hyperintense nucleus pulposus with horizontal hypointense bands and preserved disc height; (**C**) degree 3: intermediate signal intensity of the nucleous without reduction or with only a slight reduction in disc height; (**D**) degree 4: hypointense nucleus with significant loss of disc height; and (**E**) degree 5: diffusely hypointense and collapsed disc.

Table 1 Demographics and results of the pain and quality of life questionnaires

	N	Median (minimum–maximum)	First quartile	Third quartile
Age (years)	85	53 (19–69)	46	56
Oswestry Disability Index	85	44 (6–82)	28	56
Visual Analog Scale	85	8 (3–10)	7	9

Table 2 Distribution of patients by age group

	Frequency	Percentage
Under 20 years of age	1	1.17%
21-30 years of age	2	2.35%
31-40 years of age	6	7.06%
41-50 years of age	24	28.23%
51-60 years of age	37	43.52%
61-70 years of age	15	17.65%

(modified in 5 degrees) and the VAS. Correlations with values of $p < 0.05$ were considered significant, and the Spearman coefficient was used to evaluate the strength of the correlation. Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, United States) software, version 23.0.

Results

Characteristics of pain, quality of life and disc degeneration

A total of 85 patients were evaluated. ►**Table 1** summarizes the age and the ODI and VAS scores of the sample, while ►**Table 2** shows the distribution of patients by age group.

The frequency of the different ODI degrees and the levels of pain in the VAS are illustrated in ►**Figures 2** and **3**. In total, 8.24% of the patients had minimal disability in the ODI; 37.65%, moderate disability; 32.94%, severe disability; 20% had crippling back pain; and 1.18% (1 patient) was bed-bound. The lowest level of pain on the VAS was 3, and 64% of the patients reported a level ≥ 7.

►**Figure 4** shows the frequency of Pfirrmann degrees of degeneration at each disc level and the Pfirrmann-max in the sample of subjects. The most degenerated discs in the subjects included were L4-L5 and L5-S1, with 61.1% and 45.9% of the subjects presenting Pfirrmann ≥ 3 (moderate or marked degeneration) respectively. The least degenerated disc was L1-L2, with only 8.3% of the subjects presenting Pfirrmann ≥ 3. In total, 87% of the individuals in the group had Pfirrmann-max ≥ 3.

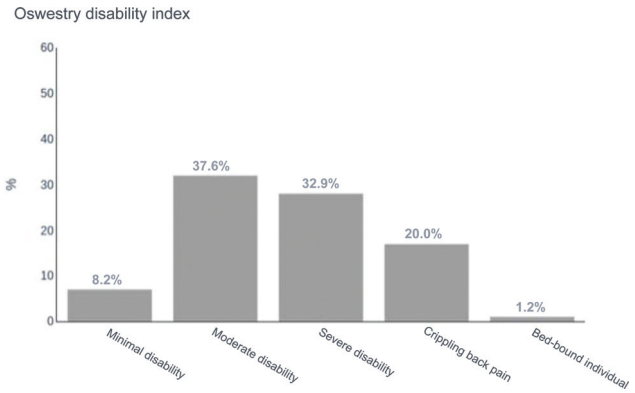

Fig. 2 Graph showing the relative frequency of the different degrees of disability according to the Oswestry disability index (ODI).

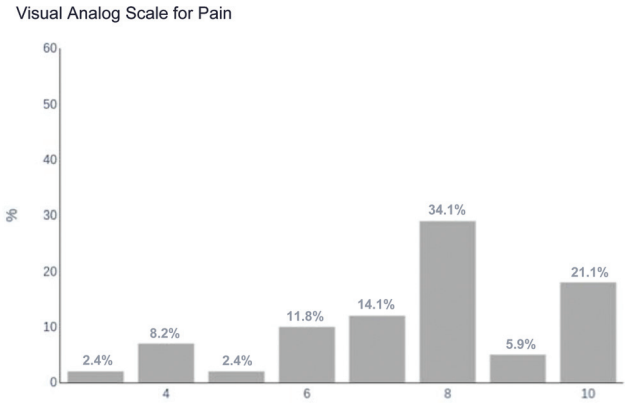

Fig. 3 Graph showing the relative frequency of pain levels on the Visual Analog Scale (VAS). The lowest level reported by the patients was level 3.

Fig. 4 Stacked bar chart showing the frequency of the different degrees of disc degeneration according to the Pfirrmann scale, at each lumbar disc level, and the maximum Pfirrmann of the sample subjects.

Relationship regarding the quality of life and pain scales and disc degeneration

►**Table 3** describes the comparison between the ODI and VAS among patients grouped according to the Pfirrmann-max found in the MRI analysis of lthe umbar discs.The mean scores on the ODI were increasing in patients with Pfirrmann-max 2 and 4-5, with a statistically significant difference between both groups ($p < 0.05$). The VAS scores were not significantly different among groups with different degrees of disc degeneration.

►**Table 4** shows the results of the correlation tests regarding the degree of Pfirrmann degeneration at each disc level, the Pfirrmann-max and the Pfirrmann-sum for all levels evaluated, and the ODI and VAS scores. Analyzing each disc level individually, we observed a weak statistically significant correlation of the degree of disc degeneration in L1-L2 and the ODI and VAS. The Pfirrmann-max and Pfirrmann-sum also demonstrated weak statistically significant correlations with the ODI.

Discussion

The present observational study aimed to evaluate chronic idiopathic low back pain and its relationship with the degree of disc degeneration assessed by MRI, according to the Pfirrmann classification.

Most of the sample (87%) had a Pfirrmann-max ≥ 3, which demonstrates that a large portion had at least one disc with moderate or marked degeneration. This finding is partially in accordance with those of previous publications that found signs of significant disc degeneration in 55.2% to 84.5%[22–24] of the patients, although we found 22.5% of discs without degeneration in the L5-S1 segment. This data demonstrates a characteristic of our sample, which may be related to the predominant age group (71.25% of patients aged between 41 and 60 years); in samples of the same age group, other authors found similar results.[25] According to other studies,[22,23,25] disc degeneration is more prevalent and accentuated in low lumbar levels, from L3-L4 to L5-S1, being more frequent and accentuated in L4-L5.

Most patients in the present study (64%) classified their pain as moderate to severe (VAS ≥ 7), and 91.97% presented a moderate or marked degree of functional disability according to the ODI, reflecting a high impact of low back pain on the quality of life of these subjects. The Pfirrmann-max and Pfirrmann-sum showed a weak correlation with the ODI, which was also observed by a previous study.[26] Although the

Table 3 Comparison between the greatest degeneration found and quality of life and pain

		N	Average ± standard deviation	Q1–Q3	Median (minimum–maximum)	*p*-value*
Maximum Pfirrmann 2		11				
	ODI		31.8 ± 10.7	26–40	30 (8–44)	0.011
	VAS		8.2 ± 1.3	7–10	8 (6–10)	
Maximum Pfirrmann 3		42				
	ODI		42.4 ± 16.8	28–54	42 (14–78)	0.094
	VAS		7.1 ± 1.9	6–8	8 (3–10)	
Maximum Pfirrmann 4/5		32				
	ODI		49.9 ± 18.9	36–64	55 (6–82)	0.011
	VAS		8 ± 1.9	7–10	8 (4–10)	

Abbreviations: ODI, Oswestry Disability Index; Q1, first quartile; Q3, third quartile VAS, visual analog scale.
Note: *p-value for the Kruskal-Wallis test for the comparison of values among 3 or more groups.

Table 4 Spearman correlation regarding Pfirrmann degrees, the Oswestry Disability Index (ODI) and the Visual Analog Scale (VAS) for Pain

	ODI		VAS	
	Spearman coefficient	*p*	Spearman coefficient	*p*
Pfirrmann L1-L2	0.288	0.008*	0.217	0.046*
Pfirrmann L2-L3	0.049	0.657	0.129	0.240
Pfirrmann L3-L4	0.121	0.269	0.065	0.557
Pfirrmann L4-L5	0.090	0.412	-0.044	0.691
Pfirrmann L5-S1	0.098	0.375	0.058	0.597
Maximum Pfirrmann	0.330	0.002*	0.140	0.201
Pfirrmann: sum of the categories	0.266	0.037*	0.064	0.559

Note: *Statistically significant Spearman correlation ($p < 0.05$).

weak correlation between the Pfirrmann grade and the ODI signals some impact of disc degeneration on the quality of life of the patients and the degree of functional disability, it suggests that other clinical, functional or anatomical factors may also play a role in disability related to low back pain.

Our results did not demonstrate a significant correlation regarding the Pfirrmann-max and the Pfirrmann-sum and the degree of pain measured by the VAS. Signs of disc degeneration are very frequent in the general population, and may affect even very young individuals, in the second decade of life[25] or even younger,[27] being very frequent in athletes.[24,28] However, the correlation between disc degeneration and low back pain in these groups is weak.[28,29] And although other authors have demonstrated that low back pain is more frequent in individuals with a higher number of degenerated lumbar discs[12] and signs of disc degeneration increase the risk of low back pain in the general population,[12,30] the direct correlation between disc degeneration and chronic low back pain remains controversial. One of the reasons is that disc degeneration is prevalent throughout the population, affecting both symptomatic and asymptomatic individuals,[28] and it is difficult to differentiate between disc degeneration related to normal aging and pathological degenerative discopathy;[11] therefore, the identification of triggering factors of discogenic low back pain is also difficult.

Another important factor to be considered is the multifactorial etiology of low back pain related to disc degeneration. Disc degeneration is a process present in habitual disc aging, which is related to dehydration and loss of disc proteoglycans. In late stages, this process culminates with the loss of support and disc shape, which impairs the maintenance of biomechanical disc support, which can overload the articular and ligamentous structures, being associated with increased instability of the lumbar spine, alteration of the shape of the disc, with the formation of bulging, fissures and protrusions. These associated factors also participate in the etiology of low back pain,[11] possibly attenuating the individual correlation of signs of disc degeneration with chronic low back pain.

Our results demonstrated a significant correlation between the degree of disc degeneration in L1-L2 and the ODI and VAS. Contradictorily, this was the least degenerated disk in our study group. These findings raise the hypothesis that lower degrees of degeneration in higher lumbar discs produce a more pronounced pain effect and a greater impact on clinical dysfunction and quality of life. A previous study[31] demonstrated that disc degeneration in the upper lumbar spine is more frequent in certain types of spine curvature or certain types of posture, with rectification of the thoracolumbar transition. These situations cause an overload on the disc, and, due to the anatomical configuration of the lumbar spine, there is a smaller dispersion of forces on the disc to the articular facets and other support structures. It has been previously suggested that increased load in vertebral structures is a factor that stimulates angiogenesis and the proliferation of neural terminations in the disc and paradiscal structures,[32] being potentially associated with discogenic pain.

Thus, we conclude that disc degeneration is quite frequent in the population with idiopathic or nonspecific chronic low back pain, affecting lower lumbar discs more frequently (L4-L5 and L5-S1). There is a weak correlation between the degree of disc degeneration measured by the Pfirrmann scale in MRI scans and the ODI scale, which suggests the presence of a certain impact of disc degeneration on the degree of functional disability and decrease in quality of life. But it also suggests that the etiology of dysfunction related to chronic low back pain is multifactorial. Although disc degeneration is less frequent in high lumbar discs, the degree of disc degeneration in the upper lumbar spine showed a higher correlation with pain and worsening of quality of life, suggesting that lower degrees of degeneration in the higher segments have a greater impact on the effects of chronic idiopathic low back pain.

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Conflict of Interests
The authors have no conflict of interests to declare.

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