CLASSIFICATION OF INTERVERTEBRAL DISC DEGENERATION BY MAGNETIC RESONANCE

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ABSTRACT

The authors suggest an analysis of the degeneration of intervertebral disks on human cadavers using magnetic resonance imaging. Nine lumbar spines were collected from fresh human cadavers and resonance images were captured. The images were analyzed and classified according to the degeneration grades, with the authors proposing a subdivision of type IV into IV-a and IV-b. Forty-four intervertebral disks were analyzed and authors found the following distribution: 4,5% type I; 40,9% type II; 32% type III and 18% type IV-a. However, the investigators disagreed with the conclusions in 4,5% of the disks. The authors found that the progressive signal lost in the T2-weighted images may be correlated to disk degeneration. Changes found in the magnetic resonance images must be standardized and classified for providing a better understanding.

Keywords: *Intervertebral disk. Magnetic resonance. Classification.*

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INTRODUCTION

Biological rationale for a healthy intervertebral disc functioning is based on cell function, which includes genetic expression for producing extracellular matrix. Over this production disc maintenance and repair occur so that it can keep the ability to hold loads required by spine. Intervertebral disc function and repair loss may be regarded as a degenerative disease of the intervertebral disc (DDD).

Collagen production varies according to age. Studies conducted by Bernick and Cailliet[1] showed a gradual reduction of cartilage formation on the growth plate from 16 years old. Antoniou et al.[2,3], in a large study, showed that the disc goes through three different phases to produce collagen: an early phase, with intense collagen production, a maturation phase with he maintenance of collagen renewal, and a third degenerative phase, when a reduced collagen production is seen.

Gruber and Hanley[4] correlated collagen changes with terminal plate and studied cell death (apoptosis) images, searching for a parallel between genetic expression and progressive disc degeneration. Roberts et al.[5] had previously demonstrated the progressive disc degeneration with terminal plate ruptures causing herniations and the Schmorl's herniation. The same author, in 1996, demonstrated the importance of proteoglycans in maintaining disc nutrition and its progressive loss resulting in a reduction of terminal plate functions.[6]

Classifications of lumbar spine degeneration by imaging methods were first provided by Modic et al.[7] In that study, Modic followed up, by magnetic resonance, the evolution of patients submitted to treatment for disc conditions with chemopapayne, classifying these changes as grade I, II or III.

Kim et al.[8] were the first ones to describe changes on disc herniation in magnetic resonance images, reporting a series of 28 patients with an accuracy of 80.6%. One year later, Kim et al.[9] published an article with a broader approach with 242 patients, showing that magnetic resonance has 92% of sensitivity, 91% specificity, and 92% accuracy, showing even better results when disc fragment sequestration was present. In 1995, Kramer[10] described a more complex classification for lumbar disc herniation, not only mentioning the size of the herniation but also its location compared to neural structures. Adding to the studies by Kim and Kramer[8-10], Militte[11] provided a new classification, recommending the use of tomography and discography. At total, these three papers represented the initial discussion about the anatomopathology of disc diseases in magnetic resonance studies.

Thompson et al.[12] were the first ones to suggest a classification for intervertebral disc degeneration disease (DDD) using a histological study. Thompson listed five assessment points ranging from age to degeneration degree.

Southern et al.[13] classified intervertebral disc degenerative disease (DDD) by magnetic resonance using human cadavers and correlating resonance finings with quantitative DICONOMETRY, a method consisting of injecting fluid into the intradiscal space and measuring intradiscal pressure, with subsequent evaluation of images change. In 2001, Pfirrmann et al.[14] advanced the studies by

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Southern with a morphological study of the disc with resonance, using a scale of 5 types, producing a good reliability. The priority in this study is to develop a classification system for disc degenerative disease (DDD) on lumbar spine. Based on magnetic resonance images at sagittal planes weighted in T2, analyses of progressive changes on disc degeneration have been made. We know that a degenerating disc shows hyposignal on T2, thus being called black disc. The authors followed the parameters described by Pfirrmann et al.[14] , such as disc structure, nucleus color, signal intensity, and disc height. This study seeks to reproduce the methods by Pfirrmann et al.[14] and Southern et al.[13], but the authors made some changes in the classification by introducing an additional type, subdividing type IV into IV-a and IV-b, considering that disc height plays a key role in its classification.

OBJECTIVES

The objective f this study is to provide assistance to clinical practice and to standardize the treatment approach for degenerative diseases of the disc by using an intervertebral disc classification with magnetic resonance imaging.

MATERIALS AND METHODS

For this study, intervertebral discs removed from cadavers of people dead for less than 24 hours sourced by the Death Examination Center of University of São Paulo Hospital das Clínicas. The procedure was made with authorization by the UNIFESP committee of medical ethics and with the approval of FMUSP's discipline of anatomy (letter attached). The pieces were removed as blocks of lumbar spine, from L1 to S1. Those anatomical pieces were then submitted to magnetic resonance test at Unifesp-EPM Imaging Department, for assessing lumbar intervertebral discs. Magnetic resonance images were taken on T1 (spin echo [tr] 700) and T2 (spin-echo[tr] 5000) at axial and sagittal planes. We collected ten spines with five discs assessed per piece. Intervertebral discs were then classified on slides weighted in T2. We assessed disc structure for image homogeneity. Nucleus was also checked for clarity and/or obscurity. Signal intensity found in the nucleus was regarded as hyper- or hypointense. Disc height was regarded as very important, so we subdivided, in this analysis group, Pfirrmann's type IV into IV-a and IV-b, because, in this parameter, an intermediate-intensity disc may already have a reduced height compared to others. We regarded type I as a homogenous-structure disc, with light nucleus, in which signal intensity is hyperintense and with normal height. (Figure 1) Type II shows structural changes with heterogeneous aspect characterized by a horizontal line; nucleus is light an with hyperintense signal; height is normal. (Figure 2) Type III has a grey heterogeneous structure, dark nucleus, with intermediate signal, but height remains normal. (Figure 3) Type IVa has a heterogeneous grey structure, with dark intermediate-signal nucleus, height is reduced, leading to a differentiation from type III. (Figure 4) Type IVb has a black heterogeneous aspect, with lost hypointense signal nucleus and reduced height. (Figure 5) Type V is distinguished from the others for being collapsed, keeping a black heterogeneous structure with lost hypointense-signal nucleus. (Figure 6) Classification grade was standardized as shown on Table 1. A classification model was prepared for assisting on images analysis. (Figure 7) All images were assessed by the radiology team and by the orthopaedics team in different days, and then conjunctively, in order to provide an agreed final classification.

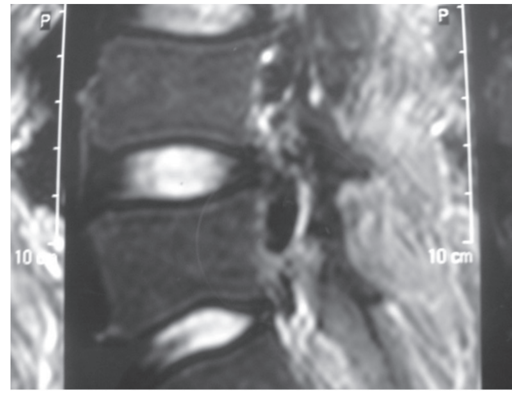

***Figure 1** - Type-I disc, with light and high, well-defined nucleus.*

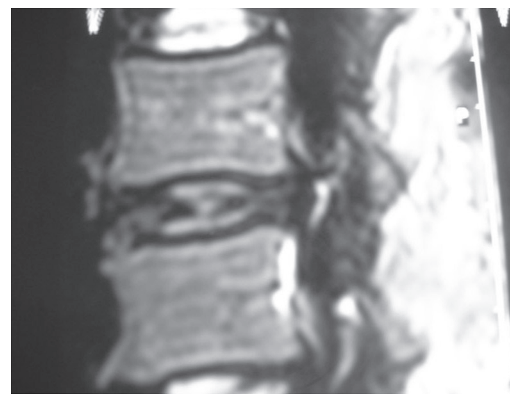

***Figure 2** - Type-II disc, nucleus with horizontal line.*

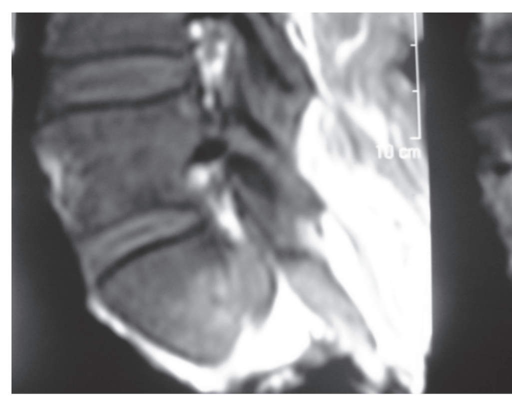

***Figure 3** - Type-III disc, grey nucleus and height maintained.*

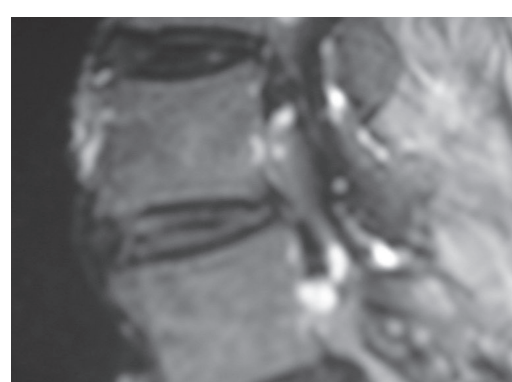

***Figure 4** - Type-IVa disc, grey nucleus, with reduced height.*

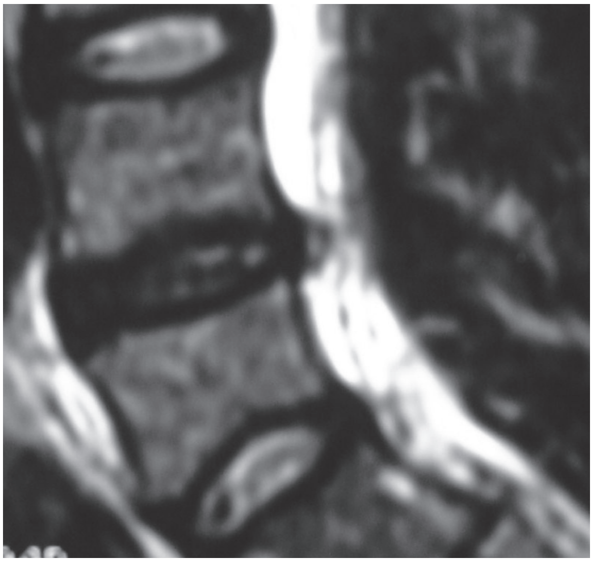

Figure 5 - *Type-IVb disc, black nucleus.*

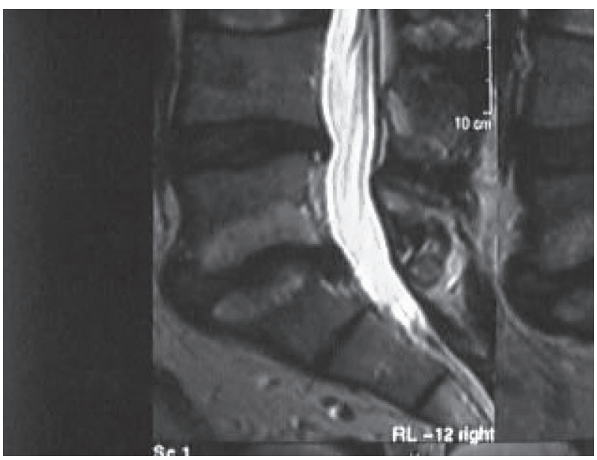

Figure 6 - *Type-V disc, with black nucleus and collapsed height.*

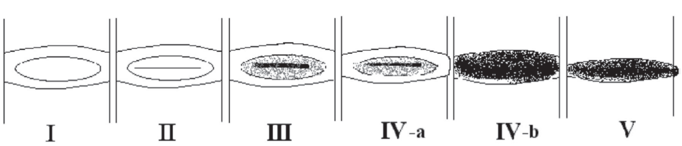

Figure 7 - *Disc classification, visual classification model for intervertebral disc as I to V.*

RESULTS

After assessing 44 discs, we set up a table with he classification of the changes found per disc. (Table 2) The authors considered 4.5% type I (2 discs), 40.9% type II (18 discs), 32% type III (14 discs), 18.1% type IVa (8 discs). There were 2 discs (4.5%) for which we reached to no consensus. In this study, the authors did not find discs with expected degeneration in IVb and V due to the random nature of the cadavers selected.

Table 2 – *Distribution of vertebral discs and their classifications. Analysis of findings of intervertebral disc classification in the different anatomical pieces studied.*

	I1/L2	L2/L3	L3/L4	L4/L5	L5/SI
01	III	III	III	II	III
02	II	II	II	III	II
03	III	II	III	II	II
04	IVA	IVA	IVA	IVA	IVA
05	I	I	II	II	III/IVA
06	II	II	III	II	IVA
07		III	II	II	III
08	III	III	III	II	IVA
09	II	II	II/III	III	IVA

DISCUSSION

Intervertebral disc classification by magnetic resonance exclusively focused on its structure has produced few articles in literature, since most authors prefer to correlate it with histological studies. Disc intensity signals are associated to chemical and histological changes[5,15,16], and changes on T2 can express the evolution of disc degeneration.[17] Differentiating gradients between the nucleus, disc height, and intensity signal on magnetic resonance are useful in the classification of disc degeneration.[14]

Bone marrow changes were assessed by other authors such as Modic et al.[7] and can still be useful for classifying disc degeneration, and may also be correlated with disc degeneration.[4]

The consistency of the changes found on the gross structure of the disc and on magnetic resonance is significant, implying on reliability of the images found. The studies by Kim et al.[8,9] in Korea

Table 1 – *Classification of intervertebral disc from I to V by assessing its structure, nucleus, signal intensity and disc height.*

Type	Structure	Nucleus	Signal intensity	Disc height
I	Homogenous	Light	Hyperintense	Normal
II	Heterogeneous with horizontal line	Light	Hyperintense	Normal
III	Heterogeneous, grey	Dark	Intermediate	Normal
IV-a	Heterogeneous, grey	Dark	Intermediate	Reduced
IV-b	Heterogeneous, black	Lost	Hypointense	Reduced
V	Heterogeneous, black	Lost	Hypointense	collapsed

show an accuracy of up to 99% for extruding and sequestrated disc herniation when compared to peroperative findings.

When we correlate imaging findings of disc degeneration with patients' symptoms of lumbar pain, some controversies can be found, since we have professional bias on the analysis of results.[18] However, most authors agree that, when nervous compression is present, the predictive value of a resonance test and patient's symptoms are quite reliable.[19]

Disc classification can be useful in clinical practice, as, for example, we know that discs with a significant height loss are not suitable candidates for arthroplasty. However, resonance studies may not detect aspects of intervertebral disc degenerative disease, such as internal disc rupture, which would only be addressed by discography in challenging tests.[15] Recently, authors such as Thalgott developed classifications to correlate not only the resonance changes but also the findings of X-ray images and discographies, enabling a better designation of indications for arthrodesis and arthroplasty.[20]

CONCLUSIONS

The authors concluded that he lost disc signal on weighted images in T2 may be correlated with progressive disc degeneration. The correlation of changes found on images produced by magnetic resonance should be standardized and classified for better understanding. The study of images captured by resonance may be of much help for clinical practice and for investigative procedures of disc degenerative disease.

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