Journal of Clinical Neuroscience 22 (2015) 346–351

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

A novel classification system of lumbar disc degeneration

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ARTICLE INFO

Article history:
Received 18 March 2014
Accepted 25 May 2014

Keywords:
Back pain
Classification
Degenerative disc
Disc degeneration

ABSTRACT

The Pfirrmann and modified Pfirrmann grading systems are currently used to classify lumbar disc degeneration. These systems, however, do not incorporate variables that have been associated with lumbar disc degeneration, including Modic changes, a high intensity zone, and a significant reduction in disc height. A system that incorporates these variables that is easy to apply may be useful for research and clinical purposes. A grading system was developed that incorporates disc structure and brightness, presence or absence of Modic changes, presence or absence of a high intensity zone, and reduction in disc height (disc height less than 5 mm). MRI of 300 lumbar discs in 60 patients were analyzed twice by two neurosurgeons. Intra and inter-observer reliabilities were assessed by calculating Cohen's κ values. There were 156 grade zero ("normal"), 50 grade one, 57 grade two, 26 grade three, 10 grade four, and one grade five ("worst") discs. Inter-observer reliability was substantial (κ = 0.66 to 0.77) for disc brightness/structure, Modic changes, and disc height. Inter-observer reliability was moderate (κ = 0.41) for high intensity zone. Intra-observer reliability was moderate to excellent (κ = 0.53 to 0.94) in all categories. Agreement on the total grade between reviewers occurred 71% of the time and a difference of one grade occurred in an additional 25% of cases. Lumbar disc degeneration can be graded reliably by this novel system. The advantage of this system is that it incorporates disc brightness/structure, Modic changes, high intensity zone, and a rigid definition of loss of disc height. This system might be useful in research studies evaluating disc degeneration. Further studies are required to demonstrate possible clinical utility in predicting outcomes after spinal treatments such as fusion.

1. Introduction

The Pfirrmann and modified Pfirrmann classification systems can be used to grade lumbar disc degeneration [1,2]. While both systems are reliable, neither is widely used in the literature. The lack of widespread application of both systems may be due to their classification of discs based on structure and signal intensity without accounting for other factors that may be relevant. While both systems attempt to incorporate disc height, neither system does so in a manner that is typically used in clinical practice. In addition, neither system accounts for the presence or absence of Modic changes or a high intensity zone (HIZ).

A MRI based classification system that evaluates disc structure and brightness, presence or absence of Modic changes, presence or absence of a high intensity zone, and reduction in disc height may be useful for research and clinical purposes. Loss of disc structure and brightness are the hallmarks of radiographic lumbar disc degeneration [3,4]. Modic changes are also likely an indication of lumbar degeneration. Many studies have concluded that these endplate abnormalities are consistent with bone marrow edema and may cause pain [5–7]. In addition, the HIZ is another indicator of lumbar degeneration. Histological studies have confirmed the HIZ is a tear in the posterior annulus with subsequent infiltration by inflammatory cells [8]. Lastly, reduction in disc height is another hallmark of lumbar degeneration. A loss of disc height greater than 5 mm has been correlated with a favorable response to lumbar fusion [3,9].

We are not aware of a grading system that incorporates these factors and is easy to apply. The lack of a standardized grading system that includes multiple radiographic findings may hinder progress in the study of lumbar disc degeneration. Multiple investigators have studied fusion for lumbar disc degeneration and describe or grade the degree of degeneration in several different ways [10–13]. This lack of standardization makes it difficult to compare data and results from these different studies. Therefore, we feel a standardized, MRI based method of grading lumbar disc degeneration that is easy to apply may be useful. In this paper,

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http://dx.doi.org/10.1016/j.jocn.2014.05.052
0967-5868/

we present and assess the reliability of a classification system that incorporates multiple radiographic indicators to grade the degree of degeneration at each level in the lumbar spine.

2. Methods

2.1. Lumbar disc degeneration classification system

A point system for lumbar disc degeneration was developed that included four different categories (Table 1, Fig. 1). (1) Classification of disc structure and brightness: 0 points was assigned for presence of a distinct annulus fibrosis and nucleus pulposus, with nucleus pulposus T2-weighted signal intensity that was isointense to cerebrospinal fluid (CSF), 1 point for lack of a distinction of annulus fibrosis and nucleus pulposus with signal hypointense to CSF on T2-weighted images but not completely dark, and 2 points for lack of a distinction of annulus fibrosis and nucleus pulposus with a completely hypointense signal on T2-weighted images (i.e. a completely "black" or "dark" disc). (2) Modic [5] type I or type II changes: 0 points was assigned if absent, and 1 point if present. (3) HIZ, defined by Berg et al. [14] as an "area of high-signal intensity in the posterior annulus fibrosis that is brighter than the nucleus pulposus on T2-weighted images and is surrounded superiorly, inferiorly and anteriorly by the low-intensity (black) signal of the annulus fibrosis". Zero points was assigned if absent, and 1 point if present. (4) Disc height: 0 points was assigned if greater than or equal to 5 mm, 1 point if less than 5 mm. The points from each of the four categories were added to give each lumbar disc a score (possible range 0–5): grade zero (normal level) = 0 points, grade one = 1 point, grade two = 2 points, grade three = 3 points, grade four = 4 points, and grade five (severely degenerated level) = 5 points.

2.2. Rationale for this classification system

2.2.1. Disc height

The Pfirrmann and modified Pfirrmann classification systems are both reliable systems currently used to classify lumbar disc degeneration [1,2]. Both systems grade lumbar disc degeneration based on disc structure, signal intensity, and disc height. The advantage of the Pfirrmann system is its simplicity, with only five grades (Grade I to Grade V), however the disadvantage is the subjective grading of disc height. The modified Pfirrmann system addresses this shortcoming by providing a more objective description of disc height based on percent collapse, but translates into a more cumbersome system with eight different grades. Furthermore, Griffith et al. [2] do not provide a clear rationale for using 30% and 60% reduction in disc height to demarcate different grades of disc degeneration.

Table 1
Lumbar disc degeneration classification system.

Radiographic indicator of disc degeneration	Description	Points
Disc structure and brightness	Presence of a distinct annulus fibrosis and nucleus pulposus; nucleus pulposus T2-weighted signal isointense to CSF	0
	Lack of a distinction of annulus fibrosis and nucleus pulposus; nucleus pulposus T2-weighted signal hypointense to CSF but not completely black	1
	Lack of a distinction of annulus fibrosis and nucleus pulposus; nucleus pulposus T2-weighted signal completely hypointense (black or dark disk)	2
Modic changes	No Type I or Type II changes	0
	Type I or Type II changes present	1
High intensity zone	Absent	0
	Present	1
Disc height	Greater or equal to 5 mm	0
	Less than 5 mm	1

CSF = cerebrospinal fluid.

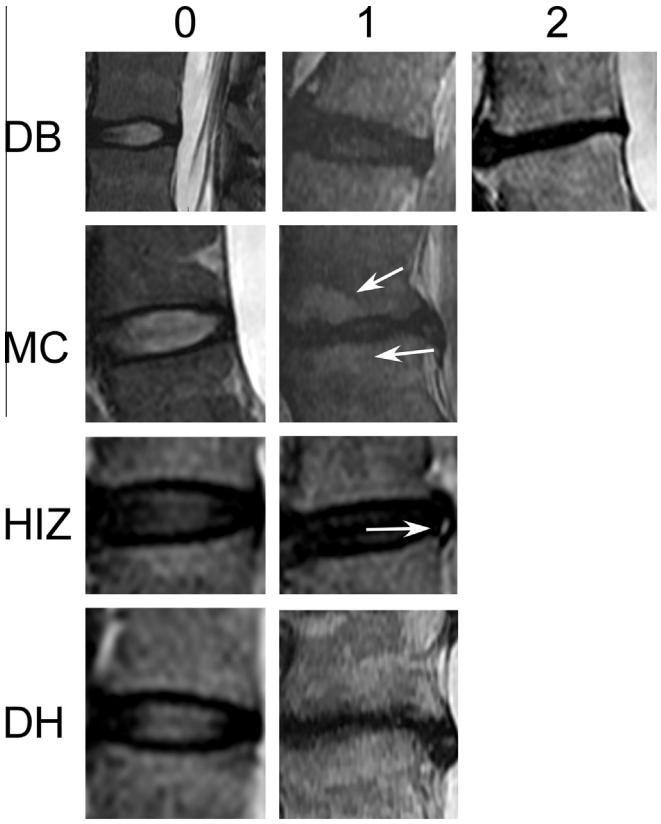

Fig. 1. Multiple sagittal T2-weighted MRI demonstrating several discs and our grading system. Top row: disc brightness (DB) with discs graded 0, 1, and 2. Second row: Modic changes (MC) with discs graded 0 (absent) or 1 (present) (white arrows). Third row: High intensity zone (HIZ) with discs graded 0 (absent) or 1 (present) (white arrow). Bottom row: Disc height (DH) with discs graded 0 (greater or equal to 5 mm) or 1 (less than 5 mm).

We think the measured height of the disc is more useful than describing the percent reduction in disc height. Two different groups have demonstrated that patients with low back pain presumed to be secondary to disc degeneration had a more favorable outcome following lumbar fusion with a disc height less than 5 mm. Schuler et al. [9] retrospectively analyzed outcomes in 392 patients with discogenic pain undergoing a fusion and noted that patients with a pre-operative disc height of less than 5 mm had the best clinical improvement. Djurasovic et al. [3] retrospectively studied multiple radiographic factors following lumbar fusion and identified that patients undergoing lumbar fusion with a pre-operative disc height less than 5 mm demonstrated the greatest improvements in clinical outcome measures. Given the consistent findings of these two studies, we assigned 1 point to any disc with a height less than 5 mm. Zero points were assigned for discs with a height equal to or greater than 5 mm.

2.2.2. Disc structure and signal intensity

To classify disc structure and signal intensity, we felt the five levels of the Pfirrmann [1] grading system could be further simplified. In our system, we assign 0 points for presence of a distinct annulus fibrosis and nucleus pulposus, with nucleus pulposus