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Several concerns on grading lumbar disc degeneration on MR image with Pfirrmann criteria

Letter

Several concerns on grading lumbar disc degeneration on MR images with the Pfirrmann criteria

The Pfirrmann criteria for grading lumbar disc degeneration was published in 2001 by Pfirrmann and his colleagues [1]. Their goal was to develop a classification system for lumbar disc degeneration based on routine T2 weighted magnetic resonance (MR) images. According to Pfirrmann et al., grade-1 disc nucleus has a homogeneous bright white structure; grade-2 disc nucleus has an inhomogeneous white structure with possible horizontal bands; grade-3 disc maintains a clear distinction between the dark annulus and white nucleus; grade-4 disc does not show a distinction between annulus and nucleus, while grade-5 disc has a collapsed disc space. In their original paper, these grading criteria were tested on a relatively small number of MR images of 300 lumbar discs in 60 patients (33 men and 27 women) with a mean age of 40 years (range: 10–83 years), which included 20 examinations of subjects between the ages of 10 and 20 years. According to the consensus reading, Pfirrmann et al. reported that in their samples there were 14 grade-1 (4.7%), 82 grade-2 (27.3%), 72 grade-3 (24%), 68 grade-4 (22.7%), and 64 grade-5 discs (21.3%). For the results by three independent readers, the inter-observer kappa coefficients ranged from 0.69 to 0.81. Complete agreement was achieved in a range from 233 (77.7%) to 257 (85.7%) of all 300 discs. A difference of one grade occurred in 43 (14.3%) to 71 (23.7%) assessments of the discs, while a difference of two grades occurred in two discs (0.7%) and a difference of three grades in one disc (0.3%). The Pfirrmann criteria quickly became popular among researchers and have been widely applied in research articles. A google search on 15 November 2021 showed it had been cited by 3292 articles, and a Web of Science search on 15 November 2021 showed it had been cited by 2009 articles. Griffith et al. [2] once suggested that the 5-level Pfirrmann grading criteria for disc degeneration did not prove sufficient discriminatory, and an 8-level modified grading system for disc degeneration was proposed.

In this letter, I discuss several concerns on the Pfirrmann criteria for lumbar spine degeneration grading.

1. The original description of Pfirrmann et al. [1] did not clarify what constitutes a ‘disc space collapse’, and how to deal with moderate disc space narrowing was not addressed. Disc space narrowing is commonly considered a sign of disc degeneration [3,4]. In common practice, applying both Pfirrmann 5-level grading and Griffith's 8-level grading schemes, a higher degree of disc space narrowing leads to higher disc degeneration scores. However, osteoporosis is associated with vertebral height loss, particularly vertebral middle height loss, which allows the expansion of the disc vertically [5–7]. We did a study quantitatively measured lumbar disc dimension in elderly subjects [7], and demonstrated that lower lumbar bone mineral density (osteopenia and osteoporosis) was associated with a decrease in lumbar disc anterior height and posterior height; however, the middle height of the discs was increased (therefore the disc biconvexity index was increased). Thus, an osteoporotic spine is less likely graded as having disc space narrowing, and thereof, less likely graded as having disc degeneration (or would likely being graded as a lesser degree of disc degeneration) [8]. If two cohorts' MR images had similar disc nucleus signal darkening while the subjects in one cohort had osteoporosis while the subjects in the other cohort did not have osteoporosis, then the cohort with osteoporosis subjects will have the risk of being graded as having a lesser degree of disc degeneration [8]. Therefore, Pfirrmann criteria for lumbar spine degeneration is less applicable in elderly subjects, particularly elderly female subjects among whom osteoporosis is very common. We suggest that morphological disc space narrowing (or collapse) and disc biochemical degeneration as reflected by MR imaging signal changes, should be graded separately [8]. Otherwise, faulty conclusions such as osteoporosis protecting the discs from degeneration could be drawn [8]. With the recent development of MR technologies, MR based metrics which provide quantification of biochemical composition of disc tissues, such as T2, T1rho, can be quickly obtained [9,10]. T1rho has been shown to be advantageous in assessing the degeneration of annulus [11].
2. In the original article of Pfirrmann et al. [1], grade-1 disc was described as a homogeneous bright white structure. However, such grade-1 discs would be very rare in a patient population. Even healthy lumbar discs in young subjects often contain a grey horizontal band called intranuclear cleft. Aguila et al. [12] studied three cadaver spines, 40 patients who were symptomatic for lumbar disc disease, and ten healthy subjects were examined by MRI. They reported an intranuclear cleft was present in all normal discs in both control and symptomatic subjects who were 30 years of age and older. This intranuclear cleft appears identical to annular tissue both on T2 weighted images and histologically and represents a normal anatomic structure and appears to be a constant feature in subjects 30 years of age or older. In the description of Pfirrmann et al. [1], ‘horizontal bands’ appeared in the grade-2 discs, not in grade-1 discs.
3. Pfirrmann et al. [1] commented that the signal loss of the disc on T2-weighted MR images correlates with the progressive degenerative changes of the intervertebral disc. However, loss of the bright signal on T2 weighted image can also be due to natural aging, rather than disc degeneration alone [13,14]. The classification of “degenerated

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disc'' according to Pfirrmann et al. and Griffith et al. does not compel the reader to differentiate the pathologic degeneration from the normal consequence of aging. Moreover, there are two types of disc degeneration [15]. 'Endplate-driven' disc degeneration involves endplate defects and inwards collapse of the annulus, which has a high heritability, mostly affects discs in the upper lumbar and thoracic spine, often starts to develop before age 30 years. 'Annulus-driven' disc degeneration involves a radial fissure and/or a disc prolapse, has a low heritability, mostly affects discs in the lower lumbar spine, develops progressively after age 30 years [15].

4. Though severe disc space narrowing is usually associated with a reduced disc nucleus signal; it is not always so. Occasionally, a high disc nucleus signal can coexist with disc space narrowing at the same level. The Pfirrmann criteria did not provide a solution for this problem, though this issue was encountered in their original study. Pfirrmann et al. [1] described that in their study cases 'with disagreements of two and three grades referred to disc spaces with marked narrowing of the disc height and normal to slightly decreased signal of the nucleus'.
5. As Pfirrmann et al. initially noted, to determine whether the L5/S1 disc space is narrowed or collapsed can be tricky sometimes [1]. L5/S1 disc may need to be analysed separately.

In conclusion, Pfirrmann criteria for lumbar spine degeneration are less applicable for elderly subjects with osteoporosis, and more quantitative or more comprehensive criteria are preferred [8,15].

Declaration of competing interest

The author declares no conflict of interest.

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Yi Xiang J. Wang
Department of Imaging and Interventional Radiology, Faculty of Medicine, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong
E-mail address: yixiang_wang@cuhk.edu.hk.