How Should We Grade Lumbar Disc Herniation and Nerve Root Compression? A Systematic Review

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Published online: 14 May 2014
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Abstract

Background MRI is the gold standard for evaluating the relationship of disc material to soft tissue and neural structures. However, terminologies used to describe lumbar disc herniation and nerve root compression have always been a source of confusion. A clear understanding of lumbar disc terminology among clinicians, radiologists, and researchers is vital for patient care and future research. **Questions/purposes** Through a systematic review of the literature, the purpose of this article is to describe lumbar disc terminology and comment on the reliability of various nomenclature systems and their application to clinical practice.

Methods PubMed was used for our literature search using the following MeSH headings: “Magnetic Resonance Imaging and Intervertebral Disc Displacement” and “Lumbar Vertebrae” and terms “nomenclature” or “grading” or “classification”. Ten papers evaluating lumbar disc herniation/nerve root compression using different

grading criteria and providing information regarding intraobserver and interobserver agreement were identified. **Results** To date, the Combined Task Force (CTF) and van Rijn classification systems are the most reliable methods for describing lumbar disc herniation and nerve root compression, respectively. van Rijn dichotomized nerve roots from “definitely no root compression, possibly no root compression, indeterminate root compression, possible root compression, and definite root compression” into no root compression (first three categories) and root compression (last two categories). The CTF classification defines lumbar discs as normal, focal protrusion, broad-based protrusion, or extrusion. The CTF classification system excludes “disc bulges,” which is a source of confusion and disagreement among many practitioners. This potentially accounts for its improved reliability compared with other proposed nomenclature systems.

Conclusions The main issue in the management of patients with lumbar disc disease and nerve root compression is correlation of imaging findings with clinical presentation and symptomatology to guide treatment and intervention. Although it appears that the most commonly supported nomenclatures have strong interobserver reliability, the classification term “disc bulges” is a source of confusion and disagreement among many practitioners. Additional research should focus on the clinical application of the various nomenclatures.

Each author certifies that he or she, or a member of his or her immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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Electronic supplementary material The online version of this article (doi:10.1007/s11999-014-3674-y) contains supplementary material, which is available to authorized users.

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Introduction

Preventable medical errors occur at an estimated rate of 98,000 incidents per year with a total annual cost of USD 29 billion [3, 13]. One of the key components resulting in increased medical errors is ineffective communication.

Ineffective communication among healthcare professionals can result in poor patient care. In many cases, patients and nonspine professionals misinterpret the description of age-appropriate changes on lumbar MR images as pathological, leading to unnecessary psychological stress and often inappropriate referral. Physicians need reliable, accurate, and precise terminologies to describe pathology. A clear understanding of lumbar disc and nerve root compression terminology is critical to a multidisciplinary approach for making diagnostic and therapeutic decisions in lumbar disc disease. Standardizing nomenclature is critical for promoting effective communication among radiologists and orthopaedic and neurological spine surgeons.

In 2001 the North American Spine Society collaborated in a joint project with the American Society of Neuroradiology and American Society of Spine Radiology to standardize definitions of lumbar disc pathology. The published work, authored by Fardon [4], was endorsed by the Joint Section of Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons, the American Academy of Orthopaedic Surgeons, and the Current Procedural Terminology and International Classification of Diseases coding committee.

This published work has since been referred to as the Combined Task Force (CTF) classification system and defines lumbar discs as normal, focal protrusion, broad-based protrusion, or extrusion. Over the past decade, the CTF system has been widely implemented because of its simple structure and ease of learning. Despite these advantages, much is still unknown regarding the reliability and accuracy of the CTF classification as well as other proposed nomenclature systems for lumbar disc herniation and nerve root compression. The purpose of this article is to perform a systematic review to identify the common lumbar disc and nerve root nomenclature systems, focusing on those that are based on MRI, and to evaluate the reliability of each.

Search Strategy and Criteria

The US National Library of Medicine from the National Institutes of Health (PubMed) was used for our literature search. The search used the following major MeSH headings: “Magnetic Resonance Imaging and Intervertebral Disc Displacement” and “Lumbar Vertebrae” as well as the terms “nomenclature” or “grading” or “classification”. This search strategy yielded 99 articles, which were reviewed independently by each of the three authors for relevance. Case reports, purely descriptive papers, and papers focused on nuances of radiographic technique as opposed to classification were excluded. Full texts of the

selected papers were reviewed by all three authors and consensus was reached in all cases for inclusion or exclusion. After review there were 10 articles that evaluated intraobserver and interobserver agreement of various nomenclature systems classifying lumbar disc herniation/nerve root compression.

Evidence was graded using the North American Spine Society (NASS) criteria for prognostic studies by all three authors. We considered the role of the classification systems described in this review as being a prognostic tool to link imaging characteristics to patient characteristics. Although this is neither a perfect nor a complete description of the role of classification systems, the authors felt that this was the best strategy for grading quality of evidence. In the literature reviewed, there were no therapeutic interventions performed, there were no comparisons of diagnostic techniques, and there were no economic analyses performed, making the more familiar levels of the evidence system less applicable. Based on the NASS criteria for prognostic studies, a prospective comparison of patients at similar points in the disease process with > 80% followup is considered a level 1 study. We additionally reported kappa values to allow the reader to assess the reliability of the classification systems [8].

The relevant literature yielded from this search is briefly summarized (Table 1) and the evaluation and combined reliability of each classification system are presented (Table 2).

Results

The most widely studied and used grading systems for classifying lumbar disc herniation are the CTF and Jensen criteria, whereas the Pfirrmann and van Rijn criteria are most frequently studied for classifying nerve root compression (Table 1). Please refer to Appendix 1 (Supplemental materials are available with the online version of CORR[®].) for more detailed descriptions of each system.

Level 1 and 2 evidence supports that the CTF classification of lumbar disc disease and van Rijn’s criterion of lumbar nerve root compression have the greatest interobserver agreement and are the most reliable nomenclatures for describing their respective pathologies (Table 2). We found 10 articles that evaluated the interobserver agreement of various nomenclature systems classifying lumbar disc herniation/nerve root compression. The CTF classification system has moderate to substantial interobserver agreement, whereas Jensen’s classification has a moderate level of interobserver agreement [1, 5, 7, 9, 12, 14]. When compared with the nomenclature proposed by Jensen et al., the CTF classification trends toward improved interobserver agreement [1]. The Pfirrmann classification system has moderate to substantial interobserver agreement, whereas van Rijn’s

Table 1. Summary of key findings

Study	Level of evidence	Description	Conclusion
Lurie et al., 2008 [9]	2	Retrospective multicenter study evaluating observer variation between three radiologists and one orthopaedic surgeon using the CTF classification and Pfirrmann's criteria of root compression in patients with disc herniation Interobserver agreement for Pfirrmann's criteria of root compression yielded $\kappa = 0.47$ Interobserver agreement for CTF classification of disc herniation yielded $\kappa = 0.81$	Almost perfect agreement between users for CTF classification of disc pathology Moderate agreement for Pfirrmann's criteria of root compression
Imaad-ur-Rehman et al., 2012 [5]	2	Retrospective single-center study evaluating observer variation between two neuroradiologists and a neurosurgeon using Jensen's criteria of disc herniation and van Rijn's criteria of root compression in patients with suspected disc herniation/radiculopathy Interobserver agreement for Jensen's criteria of disc herniation yielded $\kappa = 0.511$ Interobserver agreement for van Rijn's criteria of root compression yielded $\kappa = 0.74$	van Rijn's criteria showed moderate agreement between users Jensen's criteria showed moderate to substantial agreement between users Disagreement regarding disc bulges and herniation were most frequent The neurosurgeon considered disc bulges as normal when they did not result in nerve root compression because no surgical treatment was required in such cases
van Rijn et al., 2005 [14]	1	Prospective single-center study evaluating observer variation between two neuroradiologists using Jensen's criteria of disc herniation and van Rijn's criteria of root compression in patients 18–70 years with suspected disc herniation/radiculopathy Interobserver agreement for van Rijn's criteria of root compression without and with clinical information yielded $\kappa = 0.77$ and 0.75 , respectively Interobserver agreement for Jensen's criteria of disc herniation without and with clinical information yielded $\kappa = 0.63$ and 0.59 , respectively	van Rijn's criteria with and without clinical information showed substantial agreement between users Jensen's criteria with and without clinical information showed moderate to substantial agreement between users Bulging discs were reported twice as often when clinical information was disclosed causing the authors to question the validity and use of this diagnosis
Pfirrmann et al., 2004 [11]	2	Retrospective single-center study evaluating observer variation between two general radiologists and an orthopaedic surgeon using their described classification in patients with suspected disc herniation/radiculopathy Intraobserver agreement $\kappa = 0.72$ – 0.77 Interobserver agreement $\kappa = 0.62$ – 0.67 There was a $r = 0.86$ correlation with intraoperative findings	Substantial strength of inter- and intraobserver agreement between users for Pfirrmann's system for grading lumbar nerve root compromise Disagreement was least frequent between the two highest grades of root compression and more frequent between the two lowest grades suggesting good ability to characterize significant findings
Arana et al., 2011 [1]	1	Prospective multicenter study evaluating observer variation between five general radiologists using CTF and Nordic nomenclature with suspected disc herniation/radiculopathy Intraobserver agreement $\kappa = 0.624$ – 0.750 (CTF) and $\kappa = 0.642$ – 0.714 (Nordic) Interobserver agreement $\kappa = 0.407$ – 0.562 (CTF) and $\kappa = 0.277$ – 0.473 (Nordic) Interobserver agreement $\kappa = 0.407$ (CTF) and $\kappa = 0.277$ (Nordic) when disc bulges considered normal and $\kappa = 0.562$ (CTF) and $\kappa = 0.407$ (Nordic) when considered abnormal	Substantial intraobserver agreement within both CTF and Nordic grading scales Trend toward improved interobserver agreement with CTF compared with Nordic nomenclature, especially when bulging discs were categorized as normal, otherwise similar in agreement showing moderate agreement between users Prevalence of bulging discs varied based on the nomenclature used

Table 1. continued

Study	Level of evidence	Description	Conclusion
Jarvik et al., 1996* [6]	1	Prospective single-center study evaluating observer variation between three neuroradiologists using Jensen classification in patients with suspected disc herniation/radiculopathy using 1.5-T MRI Interobserver agreement $\kappa = 0.39$ – 0.41	Fair interobserver agreement using Jensen classification Major disagreements between users were for the presence or absence of a disc extrusion
Brant-Zawadzki et al., 1995* [2]	1	Prospective single-center study evaluating observer variation between two neuroradiologists using two primitive classifications in symptomatic and asymptomatic patients using 1.5-T MRI Intraobserver agreement $\kappa = 0.71$ and 0.69 for nomenclatures 1 and 2 Interobserver agreement $\kappa = 0.58$ for both nomenclatures	Substantial intra- and interobserver agreement for both nomenclature types Most common disagreement was for normal versus disc bulges with next most common disagreement for disc bulge versus herniation
Solgaard Sorensen et al., 2006 [12]	1	Prospective single-center study evaluating observer variation between two general radiologists using spinal nomenclature of the CTF in patients with suspected disc herniation/radiculopathy Intraobserver agreement $\kappa = 0.78$ interobserver agreement $\kappa = 0.68$	Substantial intraobserver and interobserver agreement within observers using the CTF nomenclature
Mysliwiec et al., 2010 [10]	1	Prospective single-center study evaluating observer variation among three reviewers using the MSU classification of disc herniation and radiculopathy Very strong concordance between reviewers (88 of 90) Surgical success correlated with selection based on grading scale (all patients with size 1 lesions were excluded from surgical consideration) showed a 90%–96% and 80%–84% good to excellent outcomes on ODI at 1- and 5-year followup, respectively	MSU classification is a reliable method to objectively classify significant herniated disc disease Can serve as an adjunct to patient selection for discectomy
Jensen et al., 1994* [7]	1	Prospective single-center study evaluating observer variation between two neuroradiologists using Jensen's criteria for disc herniation without clinical information in asymptomatic patients interobserver agreement $\kappa = 0.59$	Moderate agreement between users 52% of asymptomatic patients had a disc bulge in at least one lumbar level

* Those studies performed using an older generation 1.5-T MRI; CTF = Combined Task Force; MSU = Michigan State University; ODI = Oswestry Disability Index.

classification has a substantial level of interobserver agreement (Table 2).

Discussion

MRI is the gold standard for evaluating the relationship of disc material to soft tissue and neural structures. Terminology used to describe lumbar disc herniation and nerve root compression has always been a source of confusion between healthcare providers. The purpose of this article was to perform a systematic review of the literature to identify the most commonly used lumbar disc and nerve root nomenclature systems and to evaluate the reliability of each in hopes of identifying sources of confusion within each classification

system. Based on our review of the published literature, the most commonly used and studied classification systems for lumbar disc herniation include the CTF and Jensen systems. The most commonly used and studied classification system for lumbar nerve root compression includes proposed nomenclature by Pfirrmann and van Rijn. After pooling the interobserver agreement of various nomenclature systems, there is level 1 and 2 evidence to suggest that the CTF classification of lumbar disc disease has significant interobserver agreement and van Rijn et al.'s criteria of lumbar nerve root compression has significant interobserver agreement. These nomenclature systems are the most reliable for describing lumbar disc/nerve root pathology.

The primary limitation of this study centers on the general limitation of evaluating any imaging study, which is the lack

Table 2. Reliability of various nomenclature systems

Nomenclature	Author and date	Level of evidence	Interobserver kappa
CTF	Lurie et al., 2008 [9]	2	$\kappa = 0.81$
	Solgaard Sorensen et al., 2006 [12]	1	$\kappa = 0.68$
	Arana et al., 2011 [1]	1	$\kappa = 0.407\text{--}0.562$
Jensen	van Rijn et al., 2005 [14]	1	$\kappa = 0.63$ and 0.59
	Jensen et al., 1994* [7]	1	$\kappa = 0.59$
	Imaad-ur-Rehman et al., 2012 [5]	2	$\kappa = 0.511$
	Jarvik et al., 1996* [6]	1	$\kappa = 0.39\text{--}0.41$
van Rijn	van Rijn et al., 2005 [14]	1	$\kappa = 0.77$ and 0.75
	Imaad-ur-Rehman et al., 2012 [5]	2	$\kappa = 0.74$
Pfirrmann	Pfirrmann et al., 2004 [11]	2	$\kappa = 0.62\text{--}0.67$
	Lurie et al., 2008 [9]	2	$\kappa = 0.47$
Nordic	Arana et al., 2011 [1]	1	$\kappa = 0.277\text{--}0.473$
Brant-Zawadzki	Brant-Zawadzki et al., 1995* [2]	1	$\kappa = 0.58$
MSU	Mysliwiec et al., 2010 [10]	1	Concordance 88/90

* Using 1.5-T MRI; CTF = Combined Task Force; MSU = Michigan State University.

of a reference gold standard to determine its accuracy or a clinical correlation of the imaging findings. Many lumbar disc herniations and nerve root compressions are self-limiting, so followup studies and correlations of imaging tests with clinical findings often are difficult. Verifying MRI findings of lumbar disc herniation and nerve root compression with intraoperative findings also is challenging. As a result of these limitations, the extent of this study was constrained to determine the most common classification systems in use and evaluate their reliability. Another constraint of our review was the sample size of our analysis. There were only 10 publications evaluating the interobserver agreement of various nomenclature systems classifying lumbar disc herniation/nerve root compression. The most frequently studied nomenclature system had only four articles evaluating its reliability and thus the scope of our analysis is limited by lack of robust data. Additional research is needed to improve the understanding of sources of confusion within each classification system.

In classifying lumbar disc herniation, one of the first widely used nomenclatures was proposed by Jensen et al. who separated lumbar disc herniation into four grades [7]. Although this simplified system was commonly used, confusion remained between practitioners of different medical fields with regard to the significance of various findings because this system was not universally supported across the different specialties. In an effort to standardize a classification scheme, experts in the field advocated for a uniformly supported and used system. In 2001 the governing boards of Spine Radiology, Neuroradiology, and the Spine Society came to a consensus paper describing lumbar disc herniation diagnostic categories based on size, location, and the relationship to normal disc. This publication by Fardon [4] was

widely supported and designated as the CTF classification of lumbar disc herniation. Our systematic review found that the CTF and Jensen classifications of lumbar disc herniation are the most widely substantiated nomenclatures today based on the number of publications testing them; we believe this reflects that they also are among the most widely used, if not the most widely used, although this is impossible to prove. The central issue in managing lumbar disc disease and nerve root compression is focused on correlating significant imaging studies with clinical symptomatology. Pfirrmann et al. [11] sought to establish a lumbar nerve root compression classification system that would be highly correlative with surgical and clinical findings. The Pfirrmann grading system distinguishes lumbar nerve root compromise into four categories. Because of its simplicity of use and correlative findings, the Pfirrmann classification became one of the most widely used lumbar nerve root classification systems. van Rijn et al. [14] devised a nomenclature system that dichotomized lumbar nerve root compression into root compression and no root compression in an effort to elucidate significant imaging findings. Because of its streamlined definitions, van Rijn's classification system also gained popularity. To date, the aforementioned nomenclatures are supported by the most ample research and we believe the most widely applied. Despite their popularity, few studies have critically evaluated the accuracy or consistency of these widely used nomenclatures. Not only have we progressed in our understanding of lumbar disc disease since their proposal, but our imaging studies and treatment paradigms have changed.

In our systematic review, we evaluated the interobserver reliability from publications providing level 1 and 2 evidence and found support of high interobserver reliability for the most

commonly used nomenclatures. The CTF classification system has moderate to substantial interobserver agreement, whereas Jensen's classification has a moderate level of interobserver agreement [1, 5, 7, 9, 12, 14]. To date, the CTF classification system is the most reliable scheme of describing lumbar disc pathology; however, its clinical application and correlation have not been investigated. The Pfirrmann classification showed substantial strength of both inter- and intraobserver agreement and a high correlation ($r = 0.86$) between imaging and intraoperative findings of nerve root compression. Disagreement between observers was least frequent between the two highest and most clinically significant grades of root compression. The most frequent disagreement was between the two lowest and most insignificant grades. This suggests that the Pfirrmann classification is able to accurately capture more symptomatic and clinically relevant lesions [11]. Although this study provides a surgical correlation, there is still no reference gold standard to determine the accuracy of the imaging findings and further research should focus on the clinical application of this grading system. van Rijn's classification has a substantial level of interobserver agreement trending toward being more reliable than Pfirrmann's proposed nomenclature; however, this figure may be influenced by the low prevalence of nerve root compression in their study. Despite this limitation, the interobserver reliability is comparable with other published data. To date, the nomenclature proposed by van Rijn is the most reliable system of describing lumbar nerve root pathology; however, the major unresolved issue with all of the preceding classification systems is the lack of a reference gold standard to determine the accuracy and of a clinical application for each grading system.

Recently a new classification scheme (Michigan State University classification) was described by Mysliwiec et al. [10] in 2010. The Michigan State University classification separated lumbar disc disease into different zones based purely on location. The authors theorized that the location of lumbar discs had a significant effect on symptomatology. Prospectively they applied their classification scheme to 100 patients and performed microdiscectomies on only those in Zones 2 and 3 (larger and more extensive). Their surgical success correlated with patient selection based solely on the grading scale (all patients with Size 1 lesions were excluded from surgical consideration) and their surgical results showed 90% to 96% and 80% to 84% good to excellent outcomes on Oswestry Disability Index at 1- and 5-year followup, respectively. Each patient was selected after an independent evaluation by three of the authors (LWM, JC, GPE [10]). There was a very strong concordance between reviewers when using the Michigan State University classification (88 of 90). Although a kappa value was not calculated, this article supports the idea that a location-based system/extent may be helpful for assessing surgical indications. This article suggests that the Michigan State

University classification is a reliable method to objectively classify significant lumbar disc disease and can serve as an adjunct to patient selection for single-level discectomy [10]. Future studies should mirror the work published by Mysliwiec et al. and focus on the clinical application of nomenclature systems.

An important issue in the management of patients with lumbar disc disease and nerve root compression is correlation of imaging findings with clinical presentation and symptomatology to guide treatment. Being able to describe characteristics of disc disease or nerve root compression associated with the high risk of failure to respond to conservative management and require intervention is crucial. The CTF and van Rijn's classification systems have strong interobserver reliability and are useful for the communication of MRI characteristics between clinicians. There is not yet evidence to suggest that these classification systems are useful as adjuncts to patient selection for guiding treatment. Future research should focus on the clinical importance of features described by these reliable and widely used nomenclature systems.

Acknowledgments We thank Dr Reitman for the opportunity to contribute to the CORR[®] symposium on disc herniation as well as our supporting institution, faculty, and staff.

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