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Consensus conference on core radiological parameters to describe lumbar stenosis - an initiative for structured reporting

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Abstract
Purpose To define radiological criteria and parameters as a minimum standard in a structured radiological report for patients with lumbar spinal stenosis (LSS) and to identify criteria and parameters for research purposes.
Material and methods All available radiological criteria and parameters for LSS were identified using systematic literature reviews and a Delphi survey. We invited to the consensus meeting, and provided data, to 15 internationally renowned experts from different countries. During the meeting, these experts reached consensus in a structured and systematic discussion about a core list of radiological criteria and parameters for standard reporting.
Results We identified a total of 27 radiological criteria and parameters for LSS. During the meeting, the experts identified five of these as core items for a structured report. For central stenosis, these were "compromise of the central zone" and "relation between fluid and cauda equina". For lateral stenosis, the group agreed that "nerve root compression in the lateral recess" was a core item. For foraminal stenosis, we included "nerve root impingement" and "compromise of the foraminal zone".
Conclusion As a minimum standard, five radiological criteria should be used in a structured radiological report in LSS. Other parameters are well suited for research.
Key Points
- *The five most important radiological criteria for standard clinical reporting were selected*
- *The five most important quantitative radiological parameters for research purposes were selected*
- *These core criteria could help standardize the communication between health care providers*

Keywords Low back pain · Lumbar spine · Lumbar spinal stenosis · Magnetic resonance imaging · Structured reporting

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Introduction

An increasing number of patients suffer from complaints associated with narrowing of the lumbar spinal canal. In patients older than 65 years, the narrowing of the lumbar spinal canal has become the most frequent indication for spine surgery [14].

The North American Spine Society defines degenerative lumbar spinal stenosis as "a condition in which there is diminished space available for the neural and vascular elements

in the lumbar spine secondary to degenerative changes in the spinal canal" [47]. Since this definition focuses on the abnormality of an anatomical space, one might consider anatomical imaging as the method of choice for diagnosis. However, the literature lacks detailed specification of radiological criteria to describe whether or not stenosis is present and parameters to classify the degree of lumbar spinal stenosis [3–5]. Consequently, a commonly agreed standard for a structured radiological report is not available and radiologists inconsistently use the existing radiological criteria and parameters [3, 18].

The lack of well-defined radiological criteria and parameters to characterize lumbar stenosis has an important impact on day-to-day clinical communication and also on research. Genevay et al., reported that researchers used varying radiological criteria for patients who were included in therapeutic clinical trials for lumbar spinal stenosis [21]. Moreover, a recent review showed that only four of 63 studies described the anatomical abnormality using quantitative parameters [59]; the others used some form of qualitative or semiquantitative criteria. However, those were extremely variable [4, 21]. Imprecise and varying radiological criteria and parameters limit the interpretability and relevance of clinical studies, such as those assessing the association of radiological criteria and parameters with clinical symptoms and signs, prognosis, or treatment response.

We report the results of a multidisciplinary meeting held October 24-25th, 2012 in Zurich, Switzerland. The aim of the meeting was to define radiological criteria and parameters that should be used as a minimum standard in a structured radiological report for patients referred for suspected lumbar spinal stenosis. A further objective was the identification of radiological criteria and parameters that might be used for research purposes.

Material and methods

Institutional review board and financial disclosure statement

This work did not involve human subjects or animals. Thus, according to national laws and institutional regulations, review board (IRB) approval was not necessary. All authors declared that they had no financial interests in the meeting and this communication. All meeting participants received reimbursement of expenses. The meeting was financed from the annual budget of the Horten Center for Patient-Oriented Research and Knowledge Transfer, University Hospital Zurich, Switzerland.

Meeting preparation

As preparatory work for the consensus meeting, we systematically searched the literature for all published quantitative, semiquantitative, and qualitative radiological criteria and parameters to characterize lumbar spinal stenosis. Details on the different methods and the corresponding results have been published elsewhere [4, 59]. In addition, a Delphi survey among 21 renowned international experts in spine imaging was performed. A detailed description of the Delphi survey and its results have been published elsewhere [43]. Overall, 27 radiological criteria and parameters were identified during this preparatory work (Table 1). They served as the basis for all further discussions during the subsequent consensus meeting. A structured summary of the data including a list of the original literature regarding these 27 criteria and parameters were mailed to the meeting participants two weeks before the meeting. Care was taken that the meeting documents were received and read by all participants.

Recruitment of the meeting participants and moderator

For this multidisciplinary consensus meeting, fifteen experts were invited. Experts were from different specialties to assure a balanced discussion with the insights from a variety of medical disciplines. The number of participants (n=15) was similar to other consensus conferences [17, 40] in that it was large enough for sufficiently diverse specialty representation but small enough for an efficient meeting. The selection of the experts was based on their clinical and scientific expertise, main field of interest, availability and willingness to make a personal contribution to this meeting. National (n=10) and international experts were invited with international experts coming from the United States of America (n=3), Germany (n=1), and the United Kingdom (n=1). Most, but not all, of the national experts were associated with the multidisciplinary Lumbar Stenosis Outcome Study (LSOS) working group, which in 2010 initiated a large Swiss-based prospective multicenter cohort study focused on diagnosis and outcome of lumbar spinal stenosis [58]. The final group of participants included six fellowship-trained radiologists (four musculoskeletal and two neuro-radiologists) (G.A.; J.C.; J.H.; J.G.J.; C.W.A.P.; S.F.X.W.), three rheumatologists (B.M.; A.N.; L.W.), two senior spine surgeons (both neurosurgeons by training) (F.R.; F.P.), two senior experts trained in general internal medicine (J.S.; R.A.D.), one physiatrist (J.L.F.) and one senior spine researcher (consultant and physiatrist by training) (A.M.). The median experience of these experts in diagnosing and treating spine patients was 17.5 years (range, 5-30 years). A detailed list of all experts and their affiliations are shown in the Appendix.

To assure an unbiased and balanced allocation of speech time to individual participants, a professional moderator with a medical background (MD by training) chaired the meeting and guided the experts in a structured and systematic discussion. The moderator also was responsible for the meeting's time frame and the successful achievement of the meeting

Table 1 List of all 27 radiological criteria and parameters that were identified during the preparatory work ahead of the consensus meeting

	NO.	CRITERION OR PARAMETER
CENTRAL STENOSIS, QUANTITATIVE		
	1§	Antero-posterior diameter of spinal canal [9, 20, 23, 27, 31, 33, 37, 63, 65]
	2§	Antero-posterior diameter of contrast column (Myelography) [2, 9, 26, 30, 57, 65]
	3	Antero-posterior diameter of dural/thecal sac [30, 31]
	4	Compression of thecal sac area in % of normal mid-sagittal diameter [27]
	5	Cross-sectional area of dural tube/sac [9, 25, 36, 44, 55, 56, 63]
	6§	Ligamentous interfacet distance [27, 69]
	7§	Transverse diameter of spinal canal [33, 63]
CENTRAL STENOSIS, QUALITATIVE		
	12§	Epidural lipomatosis [10, 28, 34]
	13§	Hypertrophy of the ligamentum flavum [22, 48]
	14§	Disc pathology [11, 16, 29, 32, 41, 52, 64, 67]
	15	Compromise of the central zone [42]
	16	Reduction of posterior epidural fat [51]
	17	Redundant nerve roots of the cauda equina [24, 46, 62]
	18	Relation between fluid and cauda equina [38, 54]
	19	Sedimentation sign [7]
	20	Visual assessment of the central spinal stenosis [52]
Lateral stenosis, quantitative		
	8	Lateral recess height [13, 61]
	9	Depth of lateral recess [15, 45]
	10§	Lateral recess angle [61]
Lateral stenosis, qualitative		
	21	Compression of the subarticular area [42, 53]
	22	Nerve root compression in the lateral recess [6]
Foraminal stenosis, quantitative		
	11	Foraminal diameter [8]
Foraminal stenosis, qualitative		
	23	Foraminal nerve root impingement [5, 35, 50, 67]
	24	Size and shape of the foramen [52]
	25§	Hypertrophic facet join degeneration [1, 19, 49, 60, 66, 67] [53]
	26	Compromise of the foraminal zone [42]
	27	Perineural intraforaminal fat [39, 68]

Note: §=criteria and parameters excluded due to overlap with other parameters, being limited to a specific imaging modality, lack of relevance or the fact that the criteria or parameter describes an underlying cause of lumbar spinal stenosis rather than the stenosis itself

goals. A two-hour briefing with the moderator was held eight weeks before the meeting.

Structure of the meeting and systematic discussion

The meeting language was English and all participants agreed to have the meeting recorded in writing, and with audiotape and videotape. The moderator operated with the goal of achieving consensus. He explained the aims of the meeting and, as a first step, guided the participants in a discussion about the importance of standard reporting, usefulness of radiological criteria and parameters, the different modalities available for lumbar spine imaging, and possible categorizations for radiological criteria and parameters. Care was taken to use terminology and definitions of the radiological criteria and parameters according to the corresponding original reports (Table 1). It was not the aim of the meeting to modify or optimize individual criteria and parameters.

As a second step, the moderator asked the participants to identify those criteria and parameters that could be excluded due to overlap with other parameters, being limited to a specific imaging modality, or limited relevance. We excluded other criteria or parameters if they described an underlying cause of lumbar spinal stenosis rather than the stenosis itself. We did not further discuss excluded criteria.

Then, as the third step, the moderator initiated detailed discussion of the remaining radiological criteria and parameters. All experts agreed that a point-by-point review would be necessary, and they agreed to create a scoring system for objective evaluation of which criteria or parameters should be used in a standard clinical report. With discussion, the experts recognized that the scoring system for quantitative criteria or parameters should be different from scoring for qualitative criteria or parameters due to the different needs. Thus, we developed two different five-point scoring systems (Online Table 1) using the following five measures:

For quantitative radiological criteria or parameters: (a) reproducibility and reliability, (b) feasibility of creating a universal threshold discriminating stenosis from non-stenosis, (c) ease of measurement (e.g., simpler to measure a distance than to calculate an area), (d) ability to account for individual anatomical variation, and (e) correlation with symptoms and outcome.

For qualitative radiological criteria or parameters, the scoring included: (a) reproducibility and reliability, (b) presence in the majority of patients (high sensitivity), (c) ease of understanding (interpretability) by physicians who read the reports, (d) ability to account for individual anatomical variation, and (e) correlation with symptoms and outcome.

Statistical analysis

There was no formal statistical analysis. Results are presented descriptively to allow the reader to follow and understand the core points of the discussion during the meeting.

Results and consensus statement

During the in-depth discussion at the beginning of the meeting, all experts agreed that among imaging criteria and parameters, those based on anatomy and pathoanatomy provide the most important information for diagnosis and management. Anatomy-based criteria and parameters could easily be exported to the different imaging modalities (e.g. CT, MRI, etc). It was noted, however, that the choice of modality might have an impact on the reliability of a radiological criterion or parameter (e.g., reliability of measurement of a bony structure on CT versus MR images). Radiological criteria and parameters were distinguished with regard to the relevant anatomical space (central, lateral, and foraminal stenosis) and according to their quantitative or qualitative nature. Subsequent discussions and the presentation of results were based on such a categorization.

During the second step, nine parameters were excluded based on the exclusion criteria noted above (Table 1) and the remaining eighteen criteria and parameters underwent detailed point-by-point review by the experts using the aforementioned scoring systems. We summarize the results in Online Table 2 and provide additional comments below:

Central stenosis, quantitative and qualitative parameters

We did not consider any of the quantitative parameters to be an essential part of standard clinical reports. This was because of a lack of evidence regarding the correlation between the parameter and symptoms or outcome or because acquiring the parameter is difficult during the daily clinical routine. We recognized that even simple measurements are time-consuming and that this often hinders radiologists in applying quantitative parameters on a routine basis. However, the group agreed that the quantitative parameters No. 3, No. 4 and No. 5 might be useful for scientific studies due to their high reproducibility [9, 25, 27, 30, 31, 36, 44, 55, 56, 63]. In research, time is a less critical factor. Experts agreed that No. 3 (antero-posterior diameter of dural/thecal sac) is easier to measure but likely less reproducible than No. 4 (compression of thecal sac, in % of normal mid-sagittal diameter) or No. 5 (cross-sectional area of dural sac). The cross-sectional area of dural sac was considered the most desirable of these three parameters if used for a clinical (outcome) study and the experts agreed that it should have the highest priority among research parameters.

The experts selected criterion No. 15, compromise of the central zone, and criterion No.18, relation between fluid and cauda equina [38, 42, 54] (Fig. 1) because both criteria can be applied in the majority of patients with central stenosis; they are easy to understand by physicians who read the reports, and both parameters consider anatomical variation. We did not include criterion No. 19, the sedimentation sign [7], criterion No. 16, reduction of epidural fat [51], and criterion No. 20, visual assessment of central spinal stenosis [52], in the core list, because they were captured in the other parameters or had low clinical relevance.

Lateral stenosis, quantitative and qualitative parameters

We did not include quantitative parameters because of their moderate reproducibility/reliability [13, 61]. However, parameters were potentially useful for research purposes. For that, the panel preferred parameter No.8 (lateral recess height) over No. 9 (lateral recess depth), because the first is easier to measure [15, 45].

Only two qualitative criteria were present in lateral stenosis [6, 42]. The difference between No. 21 (compression of subarticular area) and No. 22 (nerve root compression in the lateral recess) was unclear to the experts. Because of the fact that No. 22 is easier to understand by physicians reading reports, the panel recommended only the latter (Fig. 2). The panel discussed whether criterion No. 21 would be useful for

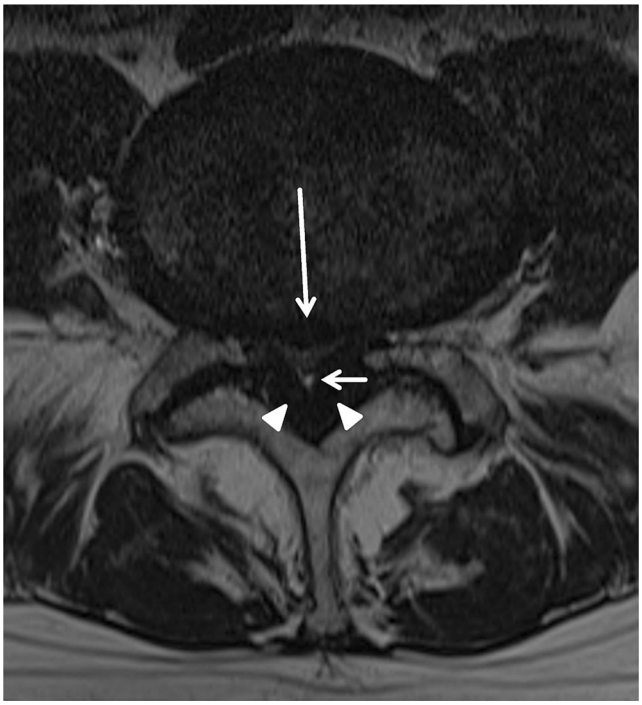

Fig. 1 Central stenosis. Axial T2 weighted MR image of the L4/L5 lumbar segment of a 71-year-old patient. According to the final set of core radiological criteria for a structured radiological report in patients with lumbar spinal stenosis, the compromise of the central zone and the relation between fluid and cauda equina should be described using the two classifications of Luire et al. and Schiza et al., respectively. Severe spinal canal stenosis with compromise of the central zone of>2/3 of its normal size due to disc material (moderate stenosis according to Lurie et al,, long arrow) and bilateral hypertrophy of the ligamentum flavum (arrow heads). No rootlets can be recognized and the dural sac demonstrates an almost homogeneous grey signal with no cerebrospinal-fluid signal visible. There is minimal epidural fat present posterior (short arrow). According to the classification of Schizas et al., the relation between fluid and cauda equina can be classified as a type C, severe stenosis

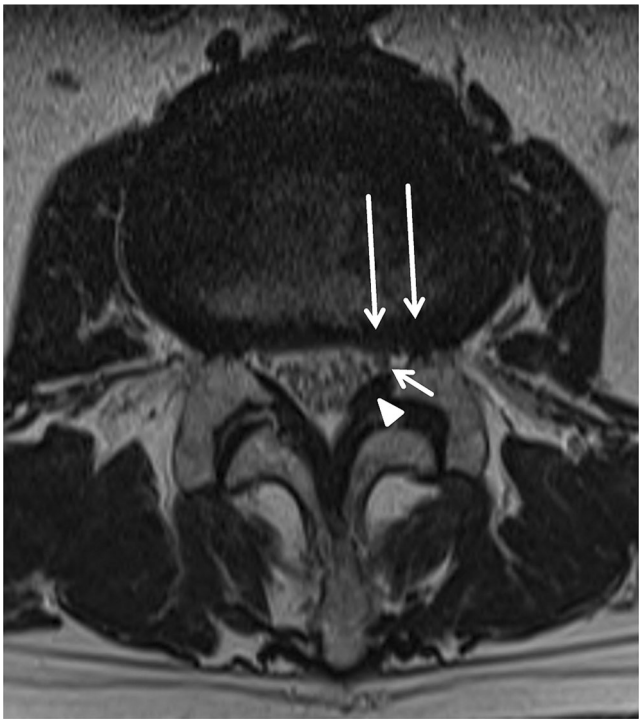

Fig. 2 Lateral stenosis. Axial T2 weighted MR image of the L4/L5 lower lumbar segment of a 67 years-old patient with left-sided accented lateral recess narrowing. According to the final set of core radiological criteria for a structured radiological report, the classification of Bartynski et al., should be used and a grade two compression should be reported. The nerve root on the left side (short arrow) is slightly compressed but with preservation of cerebrospinal fluid around the root in the recess. Reasons for stenosis are a hypertrophy of the ligamentum flavum (arrowhead) and disc material protruding in the lateral recess (long arrows)

research but agreed, that due to its similarity to No. 22, it should not be used.

Foraminal stenosis, quantitative and qualitative parameter

There was only one quantitative parameter describing foraminal stenosis, namely foraminal diameter [8]. It originated from an older CT study. Because there is too little data for this parameter using current imaging techniques, and because it did not imply any relation to the size of the nerve root, the panel agreed to exclude this parameter from the core set for standard reporting and also not to recommend this parameter for research.

Criteria No. 23 and No. 26 were selected as they are easy to understand by clinicians, and they consider the individual anatomical variation of patients [5, 35, 50, 67] (Fig. 3). As there are four descriptions of No. 23 [5, 35, 50, 67], the participants recommended using the scoring system from Pfirrmann et al. [50] because it is popular among both radiologists and clinicians.

[Summary Statement] The result of the consensus meeting includes five qualitative criteria for lumbar spinal stenosis that should be used in radiological reports (Table 2). The panel recommended using five additional quantitative parameters for clinical research.

Discussion

A panel of experts defined a core set of five radiological criteria that should be included in a radiological report for patients referred with suspected lumbar spinal stenosis. They also identified five additional parameters that might be used for clinical research.

We developed the consensus recommendations to lay a foundation for a standard report in lumbar spinal stenosis to facilitate communication among various health care providers. We based the recommendations on the state of knowledge and available data at the time of the consensus meeting. This

Fig. 3 Foraminal stenosis. Sagittal T2 weighted MR image of a 73-year-old patient with left-sided foraminal stenosis L4/5. According to the final set of core radiological criteria for a structured radiological report, the compromise of the foramen and the effect on the nerve roots should be described using the two classifications of Lurie et al. and Pfirrmann et al., respectively. Therefore, radiologists should describe the compromise of the foramen of approximately 1/3 of its normal size mainly due to disc protrusion (mild stenosis according to Lurie et al; short arrow). There is also obvious contact of disc material with the nerve root and the normal epidural fat layer around the root (see arrowheads one level above for comparison) is not preserved. This should be reported as a grade 1 impingement according to Pfirrmann et al

included the original terminology and definitions of criteria and parameters, which were used according to their original reports and not changed nor modified. We recognize that as research continues and more information is obtained, evidence may change and recommendations may have to be revised [40]. In addition, the radiological report for an individual patient, though based on a standard reporting form, can be supplemented with additional information where necessary, depending on the individual circumstances.

The use of a multidisciplinary meeting has advantages and limitations [12, 17, 40]. An advantage is that the experts have the chance to participate in an open discussion, to learn from each other's experience, and to contribute to the final consensus statement. Participants are exposed to their peers, and experts are required to argue based on facts and published evidence rather than personal experience alone, although the latter is an important part of such a meeting. As much as possible, the panel based their consensus recommendations on published evidence, though in many situations reliable evidence was lacking, resulting in final recommendations that were based on a consensus opinion of the participating experts [40]. Different views are represented due to the expertise of different medical disciplines. This may enhance the acceptance of results by the scientific community or specialized medical societies or other groups of experts.

An inherent limitation of such a consensus meeting is that any decision is influenced by the composition of the panel [12]. For this Zurich consensus meeting, we aimed for a balance between radiologists and non-radiologists with expertise in managing lumbar stenosis. Other limitations include the subjective selection of participants to invite and the imprecise definition of "expert" status. It is inevitable that, when the number of participants must be limited, not all national or international experts can be invited. Other expert groups might have reached different conclusions depending on the composition and size of the group.

We believe that the results of this Zurich consensus meeting are important with regard to clinical care of patients with

Table 2 Final set of core radiological criteria that should be used as a minimum standard in a structured radiological report in patients with lumbar spinal stenosis (LSS)

b		No.	Criteria or Parameter	Reference
Central Stenosis				
	Quantitative		-	
	Qualitative			
		15	Compromise of the central zone	[42]
		18	Relation between fluid and cauda equina *	[54]
Lateral Stenosis				
	Quantitative		-	
	Qualitative	22	Nerve root compression in the lateral recess	[6]
Foraminal Stenosis				
	Quantitative		-	
	Qualitative			
		23	Foraminal nerve root impingement	[50]
		26	Compromise of the foraminal zone	[42]

Note: * There are two different descriptions of this sign from Schizas et ?al. [54], and from Lee et ?al. [38]. The one from Schizas et ?al., was chosen by the experts to be used because of the higher degree of differentiation

lumbar spinal stenosis. The standardized use of radiological criteria to describe and characterize morphological abnormalities in lumbar spinal stenosis could substantially improve day-to-day communication between radiologists and clinicians. We note that this consensus meeting had no influence on the criteria or parameters themselves. They were not revised in any way. It was not the aim to develop new radiological criteria or parameters. Thus, the advantages and limitations of the individual criteria remain and should be considered in any scientific discussion. The Zurich meeting's main achievement was to discuss and evaluate the individual radiological criteria and parameters and to rank their clinical value. Our proposed core set of radiological criteria and parameters may not be the best for all situations and applications, but should be useful for the majority of clinical situations.

The results of this consensus meeting also do not solve the uncertainties in lumbar spinal stenosis that were recently outlined by several authors [3, 18]. For example, we did not solve the problem of weak associations between radiological findings and symptoms or the unknown prognostic relevance of the radiological criteria and parameters. However, we believe that consistent use of standard reporting in the future will increase awareness of those problems among physicians and radiologists, and facilitate better research. In addition, standard reports will improve the performance of retrospective clinical observational studies. Prospective clinical studies will also benefit as the comparability of clinical studies increases.

In conclusion, as a minimum standard, five core radiological criteria should be used in a radiological report describing lumbar spinal stenosis. Other parameters are well suited for research.

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