GRADING SCALE OF LUMBAR DEGENERATIVE DISEASE IN FULL SPINE X-RAY

ESCALA DE GRADUAÇÃO DA DOENÇA DEGENERATIVA LOMBAR EM EXAMES DE RADIOGRAFIA PANORÂMICA DA COLUNA VERTEBRAL

ESCALA DE GRADUACIÓN DE LA ENFERMEDAD DEGENERATIVA LUMBAR EN EXÁMENES DE RADIOGRAFÍA PANORÁMICA DE LA COLUMNA VERTEBRAL

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ABSTRACT

Objective: To present a new lumbar degenerative disease grading scale considering full spine radiography and to evaluate its inter- and intraobserver reproducibility. Methods: A total of 132 full spine radiographies in the anterior and lateral views were analyzed. The cases were independently graded by two examiners. The radiographic parameters observed were osteophytosis, loss of disc height, sclerosis and subchondral cysts, number of affected segments, deformities, and signs of instability. The grading scale was proposed as follows: Degree zero corresponded to the absence of signs of degenerative disease in the lumbar spine; Grade I – presence of signs of degenerative disease up to two segments; Grade II – involvement of three or more segments; Grade III – associated deformity or signs of instability. The intra- and interobserver reproducibility was determined by the Kappa coefficient (κ) in general and according to the age group. Results: Kappa coefficient obtained for interobserver and intraobserver analysis showed excellent overall correlation (0.855 and 0.902, respectively). When analyzed according to age, results obtained in intraobserver correlation remained excellent ($\kappa > 0.8$) in all age groups. The interobserver correlation remained excellent, except in the age range of 40-59 years ($\kappa = 0.773$), although maintaining a substantial reproducibility. Conclusion: The grading scale of lumbar degenerative disease observed in full spine x-rays showed excellent inter- and intraobserver reproducibility. ***Level of Evidence I; Diagnostic study.***

Keywords: Spondylosis; Spine; Low back pain; Classification; Radiography.

RESUMO

Objetivo: Apresentar uma nova escala de graduação da doença degenerativa lombar observada em exames de radiografia panorâmica da coluna vertebral e avaliar sua reprodutibilidade inter e intraobservador. Métodos: Foram avaliados 132 exames de radiografia total da coluna vertebral (panorâmica) nas incidências frente e perfil. Os casos foram graduados de maneira independente por dois examinadores. Os parâmetros radiográficos observados foram osteofitose, perda da altura discal, esclerose e cistos subcondrais, número de segmentos acometidos, deformidades e sinais de instabilidade. A escala de graduação foi proposta da seguinte maneira: Grau zero como ausência de sinais de doença degenerativa na coluna lombar; Grau I apresentando sinais de doença degenerativa até 2 segmentos; Grau II apresentando acometimento de três segmentos ou mais; Grau III quando associado com deformidade ou instabilidade. A reprodutibilidade intra e interobservador foi determinada pelo coeficiente Kappa (κ) de forma geral e conforme a faixa etária. Resultados: O Coeficiente Kappa obtido para a análise interobservador e intraobservador, mostrou excelente correlação geral (0,855 e 0,902, respectivamente). Quando analisados conforme a faixa etária, os resultados obtidos na correlação intraobservador mantiveram-se como excelente ($\kappa > 0,8$) em todas as faixas etárias. Na correlação interobservador, os resultados mantiveram-se excelentes, exceto na faixa etária de 40-59 anos ($\kappa = 0,773$), mas mantendo uma reprodutibilidade substancial. Conclusão: A escala de graduação da doença degenerativa lombar observada em exames de radiografia total (panorâmica) da coluna vertebral apresentou excelente reprodutibilidade tanto inter quanto intraobservador. ***Nível de Evidência I; Estudo diagnóstico.***

Descritores: *Espondilose; Coluna Vertebral; Dor lombar; Classificação; Radiografia.*

RESUMEN

Objetivo: Presentar una escala de graduación de la enfermedad degenerativa lumbar en radiografías panorámicas de columna vertebral y evaluar su reproducibilidad inter e intraobservador. Métodos: Se evaluaron 132 radiografías panorámicas anteriores y laterales de columna vertebral. Los casos fueron graduados de manera independiente por dos examinadores. Los parámetros radiográficos observados fueron osteofitosis, pérdida de la altura discal, esclerosis y quistes subcondrales, número de segmentos afectados, deformidades y signos de inestabilidad. La escala de graduación que se propuso fue la siguiente: Grado cero – ausencia de signos de enfermedad degenerativa en la columna lumbar; Grado I – signos de enfermedad degenerativa hasta 2 segmentos; Grado II - compromiso de tres segmentos o más; Grado II I - deformidad asociada o signos de inestabilidad. La reproducibilidad intra e inter-observador fue determinada por el coeficiente Kappa (κ) de forma general y conforme al grupo de edad. Resultados: El coeficiente Kappa obtenido en los análisis interobservador e

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intraobservador mostró excelente correlación general (0,855 y 0,902, respectivamente). Cuando se analizaron según el grupo de edad, los resultados de la correlación intraobservadores se mantuve excelente (κ > 0,8) en todas las edades. En la correlación interobservadores, los resultados se mantuvieron excelentes, excepto en el edad de 40-59 años (κ = 0,773), pero manteniendo reproducibilidad sustancial. Conclusión: La escala de graduación de la enfermedad degenerativa lumbar observada en exámenes de radiografía total (panorámica) de la columna vertebral presentó excelente reproducibilidad tanto inter como intraobservador. ***Nivel de evidencia I; Estudio diagnóstico.***

Descriptores: *Espondilosis; Columna vertebral; Dolor de la región lumbar; Clasificación; Radiografía.*

INTRODUCTION

Full spine x-ray - from the cervical spine to the elements of the hip on the same plate - has become increasingly common in patients with chronic low back pain. The association between changes in certain radiographic parameters measured in full spine x-ray and the occurrence of pain and functional incapacity is well established.[1-3] These changes were the premise for the SRS-Schwab Adult Spinal Deformity (ASD) Classification.[4] Recently, the clinical relevance of the SRS-Schwab classification has been clearly established, showing that the intensity of the functional imitation, and the choice of treatment type, were influenced by the subtypes of the SRS-Schwab classification and their modifiers.[5]

On the other hand, the functional incapacity associated with low back pain may have numerous other causes. One of the most frequent is spondylosis, a general term used to define degenerative changes in the vertebral spine.[6] Its physiopathology affects the vertebral disc, facet joints and vertebral bodies.[6] These degenerative changes may also be associated with deformities of the vertebral spine, instability and spondylolisthesis, and canal and foraminal stenosis, which may lead to compression of the neural elements as a result of joint hypertrophy and disc bulging.[7] Although the gold standard exam for evaluating degenerative changes of the vertebral spine is MRI,[8] x-ray enables the identification of signs associated with spondylosis, including osteophytosis, loss of disc height, sclerosis and subchondral cysts in the vertebral plates, as well as scoliosis, lateral listhesis and spondylolisthesis.[9]

However, there is a lack of studies evaluating the interference of degenerative changes of the lumbar spine on the association between changes in radiographic parameters and sagittal alignment of the spine, and the occurrence of symptoms such as pain and functional limitation. The aim of this study is to present a grading scale for lumbar degenerative disease observed in full spine x-rays, and to evaluate their inter- and intraobserver reproducibility.

METHODS

This is a reproducibility study of a proposed scale for radiographic grading of lumbar degenerative disease. Images were considered in the anterior and lateral views of the lumbar segment of the vertebral spine, extracted from full spine x-ray exams. With the advent of the digitalized exam, the image can be augmented to evaluate the lumbar segment more precisely, using a full spine x-ray.

The study was approved by the Institutional Review Board of the Service it was conducted (CAAE: 6020515.8.0000.5463), and uses an image bank of x-rays from patients who signed a free informed consent form relating to the storage of their images.

Graduation scale

The presence or absence of the main radiographic signs of lumbar degenerative disease were considered, including osteophytosis, loss of disc height, sclerosis and subchondral cysts in the terminal plates,[9] as well as the number of affected segments. The absence or presence of scoliosis or signs of instability was also considered, such as spondylolisthesis and lateral listhesis. The proposed grading scale was as follows:

1. Grade 0: absence of signs of lumbar degenerative disease (Figure 1).
2. Grade I: presence of signs of degenerative disease in one or two segments of the lumbar spine, without scoliosis or signs of instability (Figure 2).
3. Grade II: presence of signs of degenerative disease in three or more segments of the lumbar spine, without scoliosis or signs of instability (Figure 3).
4. Grade III: presence of signs of degenerative disease of the lumbar spine associated with scoliosis (coronal inclination measured by the technique of Cobb angle of 30° or more) and/or signs of instability, such as lateral listhesis (> 2 mm) and spondylolisthesis (at least grade 2) (Figure 4).

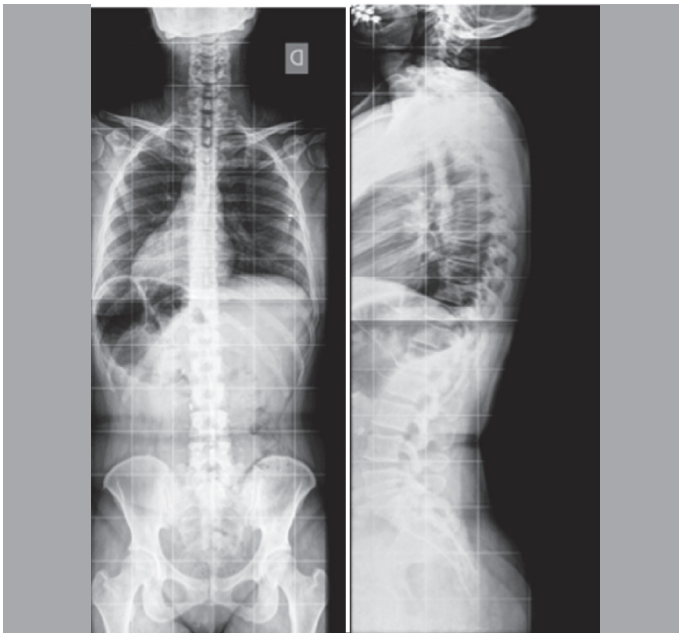

Figure 1. Example of a grade 0 patient on the scale.

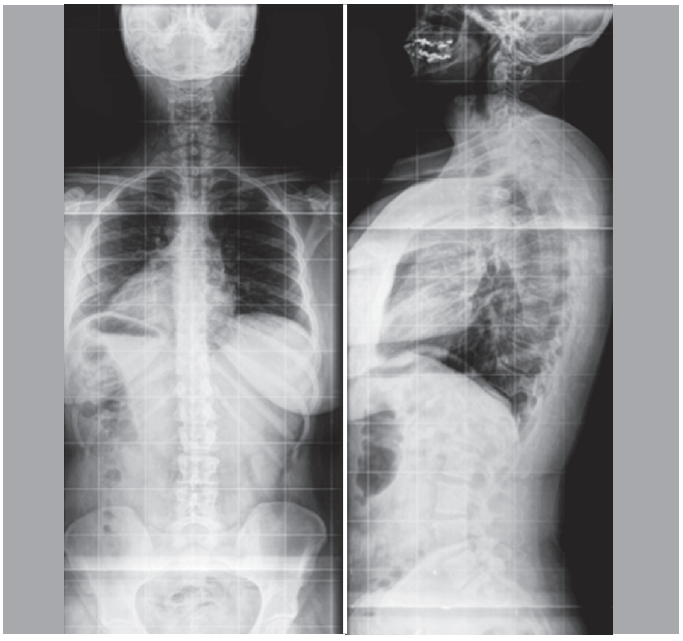

Figure 2. Example of a patient with grade I on the scale.

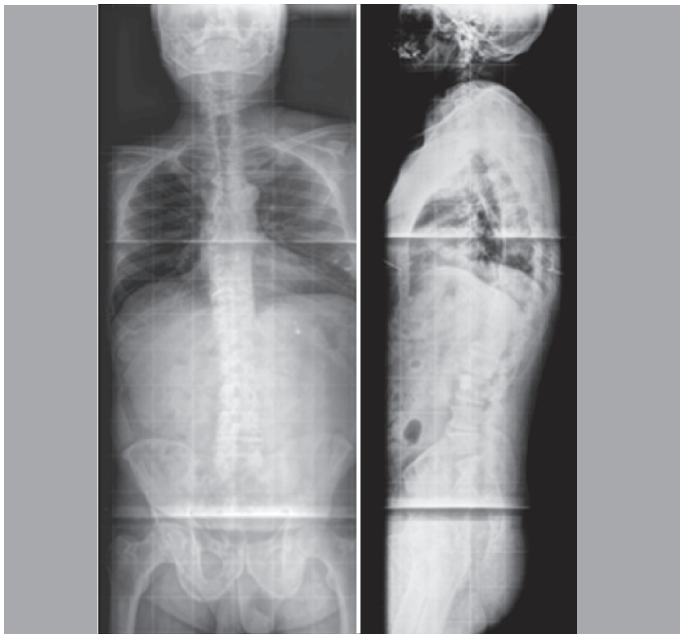

Figure 3. Example of a patient with grade II on the scale.

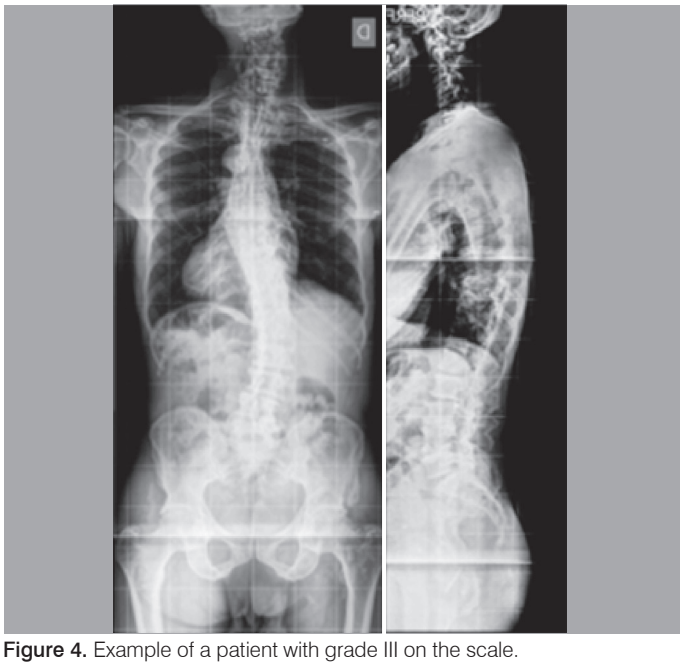

Figure 4. Example of a patient with grade III on the scale.

Evaluation of reproducibility

Full x-ray exams of the vertebral spine were considered, in the anterior and lateral views, from 132 adult patients (≥ 18 years of age) who attended the outpatient clinic. The exams were performed in the same x-ray service, following a standardized protocol: a comfortable standing posture, with the shoulders elevated 45° and the elbows flexed, and the fingertips resting on the clavicles or face.[10] All the patients were aware of the use of their exams in the study, and signed an informed consent form approved by the Institutional Review Board. Exams obtained from patients with a history of prior surgery to the vertebral spine, presence of neurological or neuromuscular diseases, history or trauma or neoplastic disease in the vertebral spine, and those with inadequate x-ray exams or exams of poor technical quality, hindering the clarity of evaluation of the lumbar segments of the vertebral spine, were excluded.

The digital versions of the x-ray images were evaluated using the software Surgimap Spine (Nemaris Inc. New York, USA), a tool validated for x-ray evaluation of the vertebral spine.[11] The cases were graded independently by two examiners, both orthopedists specializing in spine surgery; after a period of 2 months one of the examiners graded the cases again.

Statistical analysis

The statistical analysis was performed using the software IBM SPSS, version 20.0 (SPSS, Inc., Somers, NY, USA) and the tests were executed with a level of significance of 5%. The reproducibility was determined by the Kappa coefficient (κ). Interobserver reproducibility was calculated for the grades obtained by the examiners, and intraobserver reproducibility for the two grades obtained by the same examiner. The coefficients were also calculated by age group; the patients were divided into 18-39, 40-59 years, and ≥ 60 years, in order to evaluate possible variations in reproducibility according to the patients' ages.

RESULTS

Table 1 shows data on the sample of patients; of the 132 patients, 98 (74.2%) were women and 34 (25.8%) were men. The average age of the patients was 56.9 years (standard deviation ± 14.6). Considering the reproducibility of graduation of spine degenerative disease of the sample, Kappa's coefficient obtained for the interobserver analysis was 0.855 (Confidence interval: 0.793-0.917) and for the intraobserver analysis, 0.902 (Confidence interval: 0.853-0.952). Both the inter- and intraobserver reproducibility could be considered excellent ($\kappa > 0.8$).

Table 2 presents the patients distributed according to age group. Fifteen patients (11.4%) were aged between 18-39 years, 56 (42.4%) between 40 and 60 years and 61 (46.2%) were ≥ 60 years. Evaluating the intraobserver reproducibility and considering the patients in different age groups (Table 3), the coefficients obtained were excellent in all the age groups ($\kappa > 0.8$).

Analyzing the interobserver reproducibility considering the different age groups (Table 4), we found that in the patients aged between 18-39 years, and those ≥ 60 years, the coefficients remained excellent ($\kappa > 0.8$). In the age group 40-59 years, the reproducibility was considered substantial ($\kappa = 0.773$).

DISCUSSION

For a classification system to be useful, it should always be simple and reproducible. This study presents a radiographic grading scale for spine degenerative disease that obtained a high degree of intra- and interobserver reproducibility, demonstrating that it is easy to apply, consistent, and reliable. The most commonly used classification of ASD is the SRS-Schwab system, which presented high reproducibility in its validation system, with a Kappa coefficient of more than 0.8.[4]

The SRS-Schwab classification was elaborated taking into account the type of deformity in the coronal plane and the occurrence of modifiers based on radiographic parameters evaluated in the sagittal plane of the vertebral spine.[4] Various studies have demonstrated a

Table 1. Description of the sample according to the age and sex of the patients.

Sex	Sample	Mean age ± SD
Female	98	57.3 ± 14.1
Male	34	55.7 ± 16.3
Total	132	56.9 ± 14.6

Table 2. Patients distributed by age group.

Age group	N (%)
18 to 39 years	15 (11.4)
40 to 59 years	56 (42.4)
60 or + years	61 (46.2)

Table 3. Intraobserver reproducibility according to age group.

		Observer 1 (1st graduation)						
Age group	**Observer 1 (2nd grading)**	**0**	**I**	**II**	**III**	**Total**	**Weighted Kappa**	**CI (95%)**
		n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**		
18 to 39 years	0	8 (53.3)	0 (0)	0 (0)	0 (0)	8 (53.3)	0.910	(0.729; 1.092)
	I	1 (6.7)	5 (33.3)	0 (0)	0 (0)	6 (40)		
	II	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
	III	0 (0)	0 (0)	0 (0)	1 (6.7)	1 (6.7)		
	Total	9 (60)	5 (33.3)	0 (0)	1 (6.7)	15 (100)		
40 to 59 years	0	5 (8.9)	2 (3.6)	0 (0)	0 (0)	7 (12.5)	0.853	(0.755; 0.951)
	I	1 (1.8)	23 (41.1)	3 (5.4)	0 (0)	27 (48.2)		
	II	0 (0)	1 (1.8)	11 (19.6)	0 (0)	12 (21.4)		
	III	0 (0)	0 (0)	1 (1.8)	9 (16.1)	10 (17.9)		
	Total	6 (10.7)	26 (46.4)	15 (26.8)	9 (16.1)	56 (100)		
60 or + years	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.886	(0.792; 0.979)
	I	0 (0)	6 (9.8)	4 (6.6)	0 (0)	10 (16.4)		
	II	0 (0)	0 (0)	25 (41)	0 (0)	25 (41)		
	III	0 (0)	0 (0)	1 (1.6)	25 (41)	26 (42.6)		
	Total	0 (0)	6 (9.8)	30 (49.2)	25 (41)	61 (100)		

Table 4. Intraobserver reproducibility according to age group.

		Observer 1						
Age group	**Observer 2**	**0**	**I**	**II**	**III**	**Total**	**Weighted Kappa**	**CI (95%)**
		n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**		
18 to 39 years	0	8 (53.3)	0 (0)	0 (0)	0 (0)	8 (53.3)	0.910	(0.729; 1.092)
	I	1 (6.7)	5 (33.3)	0 (0)	0 (0)	6 (40)		
	II	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
	III	0 (0)	0 (0)	0 (0)	1 (6.7)	1 (6.7)		
	Total	9 (60)	5 (33.3)	0 (0)	1 (6.7)	15 (100)		
40 to 59 years	0	5 (8.9)	3 (5.4)	0 (0)	0 (0)	8 (14.3)	0.773	(0.649; 0.896)
	I	1 (1.8)	19 (33.9)	2 (3.6)	0 (0)	22 (39.3)		
	II	0 (0)	3 (5.4)	11 (19.6)	0 (0)	14 (25)		
	III	0 (0)	1 (1.8)	2 (3.6)	9 (16.1)	12 (21.4)		
	Total	6 (10.7)	26 (46.4)	15 (26.8)	9 (16.1)	56 (100)		
60 years or +	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.835	(0.723; 0.948)
	I	0 (0)	5 (8.2)	3 (4.9)	0 (0)	8 (13.1)		
	II	0 (0)	1 (1.6)	24 (39.3)	0 (0)	25 (41)		
	III	0 (0)	0 (0)	3 (4.9)	25 (41)	28 (45.9)		
	Total	0 (0)	6 (9.8)	30 (49.2)	25 (41)	61 (100)		

correlation between the spinopelvic parameters used in these modifiers and indicators of quality of life and functional capacity.[1-3]

These studies were all transversal evaluations, investigating only the association between the radiographic parameters and the outcomes considered, in this case, the quality of life indicators.[1-3] Other potential external factors were not considered and/or isolated, such as the presence of lumbar degenerative disease, its severity and extent, as well as the possible signs of instability, such as spondylolisthesis and lateral listhesis. As these signs of lumbar degenerative disease can lead to impaired quality of life and functional capacity,[11,12] it is not possible to say whether the results found in the studies correlating spinopelvic parameters with quality of life indicators were influenced by the presence and severity of the lumbar degenerative disease.

The ASD classification system proposed by Silva and Lenke,[13] unlike the SRS-Schwab system which is based exclusively on the level of deformity in the coronal and sagittal planes, addresses the radiographic signs of lumbar degenerative disease. The classification is based on lumbar degenerative disease, such as osteophytosis, but the authors mostly recommend the identification of coronal inclination with a Cobb angle > 30°, lateral subluxation > 2 mm and spondylolisthesis Meyerding grade 2,[14] as they affirm that these findings are associated with greater progression of the deformity, and recommend associating instrumentation in the surgical planning of these patients.[13] In the lumbar degenerative disease grading scale proposed here, a Cobb angle > 30°, lateral listhesis > 2 mm and Meyerding grade 2 spondylolisthesis were considered as the parameters for the highest grade, i.e. grade III.

The idea of the grading scale of lumbar degenerative disease observed in full spine x-ray exams is to be able to group patients in relation to the presence and extent of the lumbar degenerative disease. Thus, it would be possible to study spinopelvic parameters considered in the ASD within each lumbar degenerative disease group, and thereby isolate this factor of analysis. However, for it to be

considered valid, the reliability of the proposed graduation system needs to be increased, as was demonstrated in the present study. Moreover, this scale was elaborated based only on x-ray evaluation, through visualization of the lumbar segment of the vertebral spine, following the full spine exam, without the need for acquisition of complementary exam. This will facilitate future retrospective studies of patients that have only full spine radiography. In fact, based on the criteria used to grade lumbar degenerative disease under the proposed system, even a radiography of the lumbar segment of the vertebral spine, provided it is obtained with the patient in the standing position, would be sufficient. However, as it is hoped that this system will be useful for grading patients with ASD, full spine x-ray exams were considered sufficient for this study, as the best exam to evaluate these patients.

The main limitation of the present study is that the lumbar degenerative disease grading system proposed here does not consider the MRI exam, considered the gold standard for the evaluation and classification of this disease.[8] Therefore, patients attributed the same grade, according to the system proposed here, may have different grades on the Pfirrmann classification,[8] which is based on MRI exams. Moreover, it cannot be affirmed that the scale proposed here has clinical relevance, i.e. whether the indicators of pain and quality of life differ among the different degrees. This is a subject that we plan to study in the future.

CONCLUSION

We present a grading scale for lumbar degenerative disease observed in full spine x-rays. This system presented excellent inter- and intraobserver reproducibility.

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