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Comparison of the Predictive Value of Myelography, Computed Tomography and MRI on the Treadmill Test in Lumbar Spinal Stenosis

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To date, there have been no prospective, objective studies comparing the accuracy of the MRI, myelo-CT and myelography. The purpose of this study is to compare the diagnostic and predictive values of MRIs, myelo-CTs, and myelographies. Myelographies with dynamic motion views, myelo-CTs, MRIs and exercise treadmill tests were performed in 35 cases. The narrowest AP diameter of the dural sac was measured by myelography. At the pathologic level, dural cross-sectional area (D-CSA) was calculated in the MRI and Myelo-CT. The time to the first symptoms (TAF) and the total ambulation time (TAT) were measured during the exercise treadmill test and used as the standard in the comparison of correlation between radiographic parameters and walking capacity. The mean D-CSA by CT was 58.3 mm^2 and 47.6 mm^2 by MRI. All radiographic parameters such as AP diameters and D-CSA have no correlation to TAF or TAT (p>0.05). Our data showed no statistically significant differences in the correlation of the patients' walking capacity to the severity of stenosis as assessed by myelography, myelo-CT and MRI.

Key Words: Spinal stenosis, myelography, spiral computed tomography, magnetic resonance imaging, exercise test, predictive value of tests

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INTRODUCTION

As life expectancy in humans has increased, lumbar stenosis has become more common, and the number of patients undergoing surgery for lumbar stenosis is increasing.[1] As it is not feasible to perform all of the desired tests, diagnostic tools that can accurately assess the spinal stenosis pathology are required.

In the diagnosis of spinal stenosis, myelo-computed tomography (CT) and myelography have been performed routinely for some time.[2-4] Upon its introduction, magnetic resonance imaging (MRI) became increasingly popular in the diagnosis of spinal stenosis because of its non-invasiveness, its ability to analyse soft tissues, and its lack of radiation exposure.[5-7]

Currently, MRI is used frequently for the initial evaluation of stenotic symptoms. Many surgeons,[2,3] however, still prefer myelography in the diagnosis of spinal stenosis, particularly if positional components are involved in the patients' symptoms. Weight bearing is suggested to be an important factor in the diagnosis of degenerative disorders. Since spinal stenosis is a degenerative disorder in which positional components are involved, the same principle may be applied to spinal stenosis. Willen et al.[8] recommend the axial loading of the lumbar spine in the MRI to overcome the disadvantage of the non-weight bearing conditions of MRI for patients with sciatica.

Another limitation of previous studies is the lack of objective standards. In comparing the efficacy of different tests, Bischoff et al.[4] used surgical findings as the standard. The surgical assessment of stenosis, however, can be extremely subjective. Recently, the exercise stress test on a treadmill has been reported as a test that can be easily administered and can objectively quantitate the baseline functional status of lumbar spinal stenosis.[9,10] This suggests the feasibility of using the exercise stress testing on a treadmill as the objective standard in the evaluation of spinal stenosis.

The purpose of this prospective study is to evaluate preoperative exercise treadmill test data and to compare the diagnostic and predictive values of MRI, myelo-CT, and myelography.

MATERIALS AND METHODS

Patient population

For this prospective study, all consecutive patients with central lumbar spinal stenosis undergoing surgical decompression of the lumbar spine during 2001-2002 were recruited. The exercise treadmill test, myelography, meyleo-CT and MRI were performed on all patients. Thirty-five patients, 14 males and 21 females, participated in the study. Their average age was 69 years, ranging from 57 to 79 years.

The inclusion criteria were: 1) neurological claudication or sciatic pain with or without lower back pain and 2) radiographic signs of compression on the clinically afflicted dura and root(s). Additionally, the compression should not be caused primarily by herniation of the lumbar disc, neoplasm, or inflammation.

The exclusion criteria were: 1) previous back surgery, 2) multiple blocks in the myelography, and 3) other significant disorders such as spondylolithesis, polyneuropathy or arterial insufficiency.

Treadmill protocol

The preoperative and quantitative assessment of ambulation was conducted on a treadmill at a 1° ramp incline. Two tests were conducted. The first test was performed at 1.2 miles per hour (mph) and the second one at the patients' tolerable walking speed. The following information was recorded: time to first symptoms (TAF) and total ambulation time (TAT). A score of 0 was recorded if the symptoms were present at the beginning of the test. The tests were terminated at the onset of severe symptoms. Severe symptoms were defined as the level of discomfort that would make patients stop walking in normal situations. Patients were not permitted to lean forward or hold onto the handrails during the tests. Treadmill tests were conducted in the Department of Physical Medicine and Rehabilitation by a physical therapist independent of the surgical team. In addition, prior to the test, all patients were screened for medical conditions that would make the exercise test unsafe.[9]

Radiology

The myelography was obtained after lumbar induction by a standard technique using 15 mL of the contrast medium (Isovist, Schering, Germany) containing iodine (180 mg/mL). Frontal and oblique images were obtained. In addition, lateral images in the provoked weight bearing flexion and extension were obtained. The narrowest AP diameter of the dural sac in the flexion (M-flex) and the provoked extension (M-ext) were measured from the myelography, range L1-2 to L5-S1 (Fig. 1). If the narrowest AP diameter of the dura sac were blocked at multiple levels, such patients were excluded. After the myelographic examination, CT examination was performed using CT/i PRO (GE, Milwaukee, WI, USA). We chose the 3 mm slice thickness parallel to the lower endplate of the vertebra above the investigated disc for review. The pathologic D-CSA was measured on the slices through the central part of the disc (CT-D-CSA, Fig. 2-A). The mean D-CSA was calculated using the standard measurement program in the PACS system. The MRI examination was performed using the 1.5 Tesla System (Siemans, Erlangen, Germany). All patients were examined with 5 mm slices of the sagittal T1, T2 and 3 mm slices of the axial T1 images. The box for transverse slices was placed parallel to the disc (MRI-

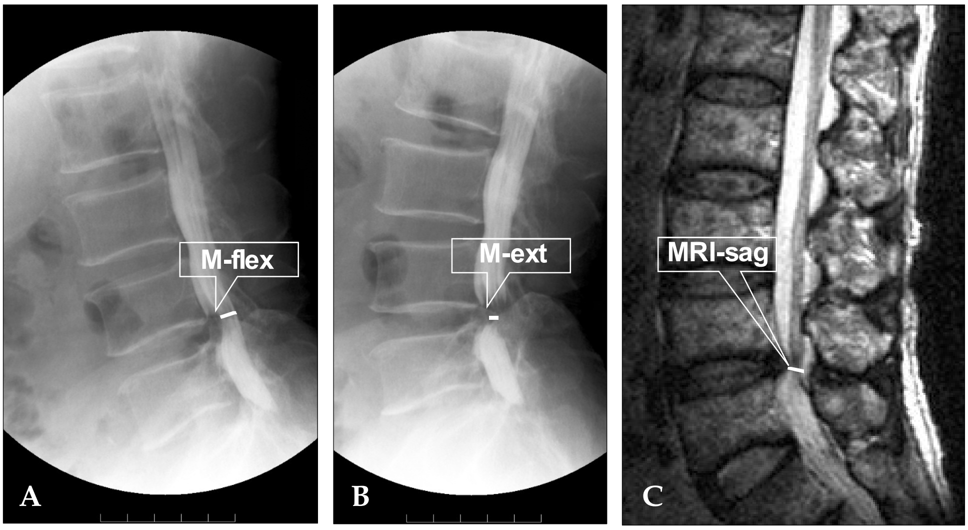

Fig. 1. Lateral projections of functional myelogram from a patient with lumbar spinal stenosis in (A) provoked flexion, and (B) extended position. Note the increase of the sagittal diameter at the third and fourth level in the flexed position.

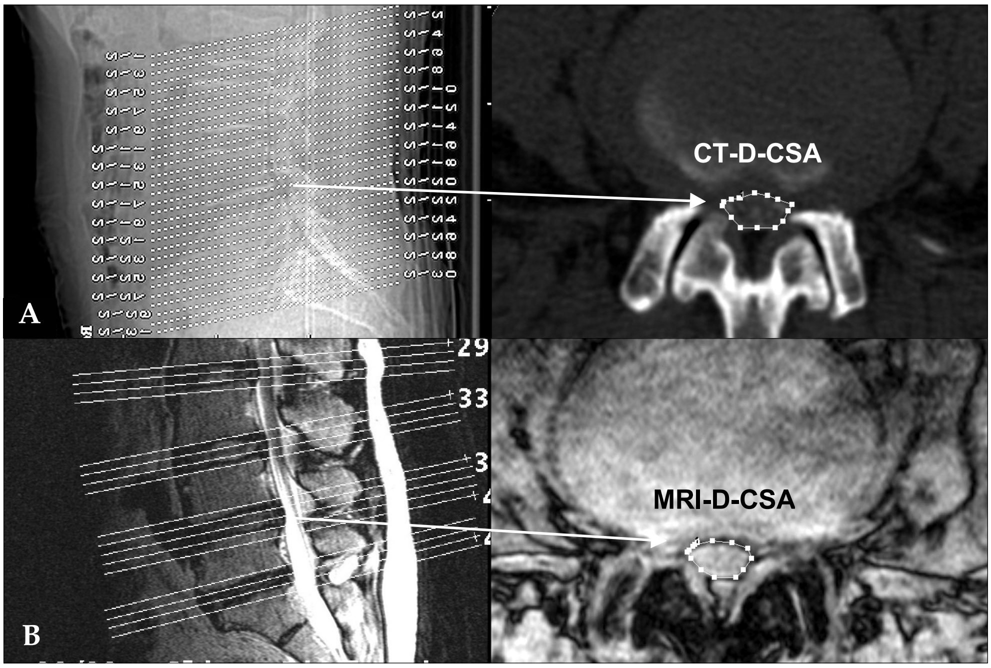

Fig. 2. (A) The CT scan slices chosen were parallel to the lower vertebral endplate. The pathologic D-CSA was measured at the disc level. (B) The MRI scan slices chosen were parallel to the lower vertebral endplate. The pathologic D-CSA was measured at the disc level.

D-CSA, Fig. 2-B).

Study parameters

The TAF and the TAT were calculated as meters. Using the calculated TAF and TAT as the standard, the correlation between the walking capacity and radiology was assessed. The parameters of the radiography were the AP diameters from the sagittal flexion and extension view of myelography, the AP diameter in the MRI sagittal image, the D-CSA in the CT, and MRI axial images.

Statistical analysis

An independent t-test was applied to the data to compare the D-CSA of CT with the MRI groups. For the analysis of three or more groups, the Spearman and Pearson correlation coefficient analysis was performed. The SAS 8.1 program (SAS Institute, Cary, NC, USA) was used for the statistic analysis.

RESULTS

The results of the treadmill and radiographic parameters are summarized in Table 1 and Table 2.

To determine reproducibility, we carried out the treadmill examination twice for each patient. Thirty-two patients (91.6%) completed the 1.2 mph trial. Three patients (8.6%) were unable to participate in the 1.2 mph test as they could not walk at that speed: one patient was in poor general condition; two patients had severe degenerative joint disease of the knee. As these three patients could walk on the treadmill at slower speeds, their walking distance was calculated based on their walking time, and the data were recorded in the preferred speed trials. In the repeated tests, the results of the baseline tests were readily reproduced (Spearman correlation coefficients, SCC=0.92). The mean TAF was 67.8 m and TAT, 240.2 m.

Compared to myelography flexion or MRI AP diameter, erect, lateral extension myelography showed a reduction in AP dimensions (4.37 ± 2.50 mm). The differences of the sagittal diameters in flexion and extension ranged from 0 to 5.5 mm. All patients showed a decrease in the diameter of the flexion view. The AP diameters in the MRI sagittal view were comparable to the average of the M-flexion and extension. As shown in Table 2, the correlation of other parameters to the TAF

Table 1. The Results of Radiographic Parameters in Lumbar Spinal Stenosis

Variable	Mean	Std Dev	Minimum	Maximum
TAF*	67 m	± 45.06	3 m	320 m
TAT†	240.2 m	± 224.5	24 m	996 m
Myelo-ext	4.37 mm	± 02.50	1 mm	10.1 mm
Myelo-flex	5.74 mm	± 02.63	1 mm	11.9 mm
MRI-ext	4.98 mm	± 01.52	2.20 mm	7.40 mm
D-CSA‡ -CT	58.31 mm^2	± 27.26	12.94 mm^2	153.07 mm^2
D-CSA‡ -MRI	47.58 mm^2	± 18.31	16.02 mm^2	112.2 mm^2

*The calculated walking distance until patients complained of the time to the first symptoms.
† The calculated walking distance until patients complained of the total ambulation time.
‡ Dural cross-sectional area.

Table 2. The Statistical Analysis between Radiographic Parameters and Walking Capacity

Variable	Myelo-ext	Myelo-flex	MRI-sag	CT D-CSA§	MRI D-CSA
SCC* with TAF† Gold Standard	0.15	0.12	0.14	0.19	-0.15
p value	0.39	0.37	0.63	0.38	0.15
SCC with TAT‡ Gold Standard	-0.43	-0.35	-0.22	-0.31	-0.27
p value	0.06	0.18	0.19	0.23	0.11

*Spearman Correlation Coefficient
† The calculated walking distance until patients complained of the time to the first symptoms.
‡ The calculated walking distance until patients complained of the total ambulation time.
§Dural cross-sectional area.

and TAT distance was not significant (p>0.05).

The maximal stenosis of the D-CSA measured by CT was $58.31 \pm 27.26\ mm^2$. The D-CSA measured by MRI was $47.58 \pm 18.31\ mm^2$, which was slightly smaller than that of CT. The difference, however, was not statistically significant.

DISCUSSION

The use of traditional clinical outcome measures to indicate the need for spinal surgery is not adequate in many areas of medicine.[11] In particular, since criteria for the evaluation of patients with back problems have been subjective and variable, the diagnostic criteria have also not been standardized.[11] It has been proven that the treadmill test is practical and its results can be reproduced readily in short-term, repeated tests. In the comparison of the functional mobility of apparently healthy subjects and patients with lumbar spinal stenosis, the treadmill walking test proved to be reproducible and reliable.[9] Furthermore, the exercise stress test on the treadmill has been reported as a method that can be easily administered and can assess the baseline functional status of lumbar spinal stenosis objectively and quantitatively.[10] In this study, we demonstrate that the exercise treadmill test is a reliable and reproducible measure for assessing the functional status of a patient.

Several studies comparing the accuracy of different radiographic tests, such as MRI and myelography, have been reported.[2,4] In Bischoff's study,[4] patients with suspected spinal central stenosis were examined by MRI, myelo-CT and myelography and their results were compared with the findings at surgery. They considered myelo-CT as the most sensitive and accurate test for the diagnosis of spinal stenosis.[4] The study, however, had several methodological limitations. When MRI was used in the initial diagnosis, the contrast study myelo-CT was performed. Since these patients underwent surgery, it is assumed that surgeons determined surgical indications based on the results of the contrast studies. Such practices may artificially decrease the accuracy of MRI and increase the accuracy of the contrast studies. Only with a prospective study in which all three measures have been checked routinely, can the proper comparison of the accuracy of different tests can be made. Another limitation of the study is the lack of an objective standard. Bischoff et al.[4] used surgical findings as gold standards. The surgical measurement of stenosis, however, can be subjective. We thus examined whether the preoperative exercise stress testing on a treadmill can be used as an objective standard.

Herno[1] classified patients with completely blocked or partially blocked myelography as the blocked stenosis group, patients with the AP diameter less than 10 mm as the absolute stenosis group, and patients with the AP diameter ranged 10 to12 mm as the relative stenosis group. They concluded that the severity of myelographic findings correlates to the outcome of the surgery for lumbar canal stenosis. Our study, however, showed a poor correlation of the exercise treadmill results to the myelography results.

In this study, the mean D-CSA of MRI axial image was $47.5 \pm 18.3\ mm^2$ and the D-CSA of the myelo-CT was $58.3 \pm 27.3\ mm^2$. Although the D-CSA of the myelo-CT is usually 20% larger than that of MRI, we think that it is a normal radiological phenomenon because of the BURR effect.[12] According to Burr's study,[12] the cross sectional area of contrast in the CT is usually 20% larger than that of the MRI due to the contrast's brightness. The obstruction degree in this study was higher than other studies.[13,14] In addition, our data demonstrated that the differences in the patients' walking capacity and the severity of stenosis assessed using the Myelo-CT or MRI was not statistically significant. We used the Pearson correlation coefficients and the statistical power was about 0.75. The results of the Spearman correlation coefficients were very close to the Pearson correlation coefficients. Therefore, we think that the statistical results of this study are useful. The poor correlation of MRI to the patient's walking capacity may have been affected by the same factors proposed for myelo-CT.

Our current findings show the poor statistical correlation of the radiographic parameters and walking capacity in patients with severe spinal stenosis. The diagnostic and predictive values of myelography, Myelo-CT and MRI are not significantly different in severe spinal stenosis.

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