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Basic Science

A comparison of two methods to evaluate a narrow spinal canal: routine magnetic resonance imaging versus three-dimensional reconstruction

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Abstract

BACKGROUND CONTEXT: In routine clinical practice, the presence of lumbar spinal stenosis (LSS) is assessed on axial magnetic resonance images (MRI) typically acquired using a preselected spine sagittal angle. Given the natural lordosis of the lumbar spine, not all axial slices will be parallel to the disc and perpendicular to the spinal canal and, thus, are not optimal for the assessment of dural sac cross-sectional area (DCSA).

PURPOSE: The objective of this study was to compare DCSA measurements from routinely acquired clinical images with three-dimensional (3D)-reconstructed images.

STUDY DESIGN: This is a cross-sectional study.

PATIENT SAMPLE: The sample consists of 390 patients referred for lumbar imaging with some aspect of anatomical LSS found, with no prior back surgery, 40 years of age or older, and with available volumetric MR images to allow 3D reconstruction of the spine.

OUTCOME MEASURES: The outcome of interest in this study was dural sac cross sectional area.

METHODS: Spine images were 3D reconstructed at the level of the disc, perpendicular to the spinal canal. Dural sac cross-sectional area was measured for both 3D-reconstructed and routinely acquired clinical images using the slice orientation captured.

RESULTS: Dural sac cross-sectional area for the lower lumbar levels (L4–L5 and L5–S1) was significantly different between routinely acquired clinical images and 3D-reconstructed images, with a standard error of measurement of 12.98 and 19.73 mm^2, respectively.

CONCLUSIONS: When canal size is of interest, particularly when LSS affecting the lower lumbar levels is of concern, 3D reconstruction of clinical images should be considered.

Keywords: Dural sac cross-sectional area; Imaging; Low back pain; Lumbar spinal stenosis; Magnetic resonance imaging

Introduction

The clinical diagnosis of lumbar spinal stenosis is currently based on history, clinical evaluation, and confirmatory imaging demonstrating central or lateral spinal canal narrowing [1–3]. The assessment of canal narrowing is conducted subjectively using nominal scales [4] (eg, mild, moderate, or severe) or quantitatively using dural sac cross-sectional area (DCSA) measurements [5,6]. When based on DCSA, measurements below 75 mm^2 have been considered stenotic [7,8].

In routine clinical practice, the presence and the degree of lumbar spinal stenosis are assessed on axial magnetic resonance images (MRI) typically acquired based on a preselected sagittal angle of the spine. Therefore, although some axial slices may be parallel to the disc and perpendicular to the spinal canal, the natural lordosis of the lumbar spine does not allow such an orientation for all slices (Fig. 1). Thus, without the technician realigning the slices before imaging acquisition considering lumbar lordosis, which is rarely done in routine clinical practice, some axial images may not be at the optimal angle for the assessment of DCSA [9,10]. In fact, a

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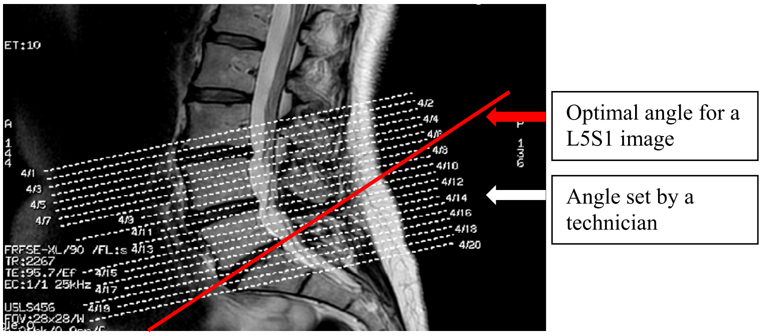

Fig. 1. As in this example, routinely acquired MRI often do not provide cuts at the proper angle to assess canal cross-sectional area. The angle set during routine clinical imaging for all axial images is contrasted with the optimal angle for analysis of DCSA at L5–S1.

recently published study demonstrated that acquiring images at different angulations (perpendicular to the spinal canal and at 10-, 20-, and 30-degree angulations) resulted in significantly different DCSA measurements [9,10].

Although the problem with slice orientation has been established [9–11], the effects of slice orientation in routine clinical practice have not been studied. Thus, the objective of this study was to compare the DCSA measurements from routinely acquired clinical images with 3D reconstructed images to evaluate the need to 3D reconstruct images for the assessment of the spinal canal. We also aimed to evaluate the impact of slice orientation on the determination of lumbar spinal stenosis using the threshold of <75 mm^2 that has been recommended [7].

Methods

Participants

We sought to obtain the necessary images for the study from participants of the Alberta Lumbar Spinal Stenosis Study who met additional study inclusion criteria. The Alberta Lumbar Spinal Stenosis Study is a prospective cohort study of 800 patients determined to have some aspect of anatomical spinal stenosis on diagnostic imaging after referral due to low back–related symptoms.

The specific inclusion criteria of the present study were:

- no prior back surgery, as surgery may influence the assessment of spinal canal,
- 40 years of age or older, as we were interested in degenerative spinal stenosis [12,13], and
- the availability of volumetric MR images to allow 3D reconstruction of the spine.

Imaging

All MR images were obtained as part of routine clinical practice at four different imaging facilities in Calgary, Alberta, using 1.5 Tesla systems. Thus, there was no standardization of MRI protocols, but T2-weighted images were available for all MRIs, which were used for the study analyses.

Imaging assessment

Clinical images

A spine researcher experienced in quantitative assessments of spine MRI identified the axial slice *closest* to mid-disc level for each spinal segment included on the MRI scan. Then, a research assistant segmented the dural sac on the selected axial slice for each disc level available from L2 to S1 using the slice orientation captured on the routinely acquired clinical images. Dural sac cross-sectional area was calculated using custom-designed image analysis software (SpEx, Version 2.73, Edmonton, Alberta, Canada).

Three-dimensional reconstructed images

Another research assistant used OsiriX software (version 3.8.1, Pixmeio, Geneva, Switzerland) for all 3D reconstruction and associated DCSA measurements. Patients' images were loaded into OsiriX and 3D reconstructed using the tools within the software. Subsequently, axial images for each spine level from L2 to S1 were extracted at the level of the disc perpendicular to the spinal canal, on which the dural sac was segmented and DCSA was calculated.

Determination of spinal stenosis

We used a value of DCSA <75 mm^2 to dichotomize whether individuals have stenosis on routinely acquired clinical and 3D-reconstructed images.

Statistical analysis

First, inter-rater reliability of DCSA measurements by the two assessors was evaluated. Independent measurements of DCSA were conducted on 60 patients' clinical images (not 3D reconstructed) using the mid-disc level previously selected. An intraclass correlation coefficient (ICC 2,1 with absolute agreement) was used to analyze the inter-rater reliability. The standard error of measurement (SEM) was calculated using the formula $SEM=SD\times\sqrt{1-R}$ (R was the reliability coefficient).

Next, the differences between routinely acquired clinical images and 3D-reconstructed images were evaluated using