European Journal of Radiology 84 (2015) 921–926

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Supine spinal magnetic resonance imaging with straightened lower extremities in spondylolisthesis: A comparison with the conventional technique

Mohammad Hossein Daghighi [a], Masoud Poureisa [a], Farid Arablou [a], Daniel F. Fouladi [b,*]

[a] Department of Radiology, Imam Reza Teaching Center, Tabriz University of Medical Sciences, Tabriz, Iran
[b] Drug Applied Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

ARTICLE INFO

Article history:
Received 21 July 2014
Received in revised form
31 December 2014
Accepted 27 January 2015

Keywords:
Spondylolisthesis
Magnetic resonance imaging
Lower extremity
Position
Lordosis
Slip

ABSTRACT

Objectives: To compare the degree of slip in spondylolisthesis on supine magnetic resonance (MR) images obtained with flexed and straightened lower extremities.
Methods: Supine spinal MR studies were performed in 100 cases of symptomatic spondylolisthesis with flexed and then straightened lower extremities. The angle of lumbar lordosis (by Cobb's method) and the degree of slip (by Taillard's method) were compared between the two sets of images.
Results: The mean angle of lumbar lordosis increased from $51.65 \pm 8.57^\circ$ on MR images with flexed lower limbs to $57.39 \pm 9.05^\circ$ on MR images with straightened lower limbs ($p < 0.001$; mean percent increase: 11.51%). Similar change was also observed for the mean degree of slip (from 25.80 ± 7.74% to 28.68 ± 7.93%, $p < 0.001$; mean percent increase: 12.60%). After MR imaging with straightened lower extremities 22 out of 54 initially grade I cases had grade II disease ($p < 0.001$).
Conclusions: Supine magnetic resonance imaging with straightened lower extremities detects higher degree of slippage in symptomatic patients with spondylolisthesis compared to conventional MRI with flexed lower extremities.

1. Introduction

Spondylolisthesis, as a common and important type of lumbar instability, is characterized by the forward displacement of a lumbar vertebra relative to the adjacent one [1].

Imaging studies are generally necessary to confirm clinical diagnosis of spondylolisthesis in symptomatic patients [2]. For planning optimal strategies of management, an ideal imaging technique should disclose maximal motion of pathologic spine [3].

Although dynamic radiography is usually considered as the method of choice for initial evaluation of patients with suspected spondylolisthesis, it is being progressively replaced by magnetic resonance imaging (MRI) [4] because it is safer and more accurate in defining vertebral slip, neural element compression, degenerative changes, and other structural abnormalities [5].

Conventional MRI in clinically suspected subjects with lumbar spinal instability is typically performed with the patient placed in the supine position with slight flexion of the hips and knees [6]. According to some reports, however, this technique may underestimate vertebral displacements in sagittal plane [7].

There are evidences that suggest hyperlordosis as a risk factor for spondylolisthesis [8,9]. At the same time, other evidences indicate that in supine position the lumbar lordosis increases from flexed to extended lower limbs [10,11]. On the basis of these evidences, it could be expected that the degree of spondylolisthesis may increase in supine position from flexed to extended lower extremities.

This study sought to compare the degree of listhesis in a group of symptomatic patients with spondylolisthesis on supine MR images acquired with flexed and then extended lower extremities.

2. Materials and methods

One hundred pairs of spinal MR studies performed in 100 symptomatic patients with final diagnosis of lumbar spondylolisthesis were reviewed in a teaching center from January 2013 through to February 2014. All patients had low back pain with or without leg pain.

* Corresponding author. Tel.: +98 9144122542; fax: +98 4113363231.
E-mail address: medicorelax@yahoo.com (D.F. Fouladi).

http://dx.doi.org/10.1016/j.ejrad.2015.01.023

The exclusion criteria were spinal tumors, spondylitis, previous lumbosacral trauma/surgery, and hip pathologies (such as degenerative joint disease).

An institutional ethics committee approved this study and written informed consents were obtained from the participants.

Spondylolisthesis was defined when an anterior translation (slip) of the cranial vertebral body on the caudal vertebral body in the sagittal plane was found on flexion/extension lumbar radiographs [4].

Radiographic diagnosis of spondylolisthesis was made by a senior radiologist with no role in this study.

The grading of spondylolisthesis was made according to the criteria defined by Meyerding [12].

Sagittal T1- and T2-weighted spinal MR images were obtained using a 1.5 T scanner (MAGNETOM Avanto 1.5 T MRI system; Siemens, Erlangen, Germany). The patients were placed in supine position and two successive images were obtained first with slight flexion of the hip and knees using a standard foam wedge, and then with straightened lower extremities [13] (Fig. 1).

Images were digitalized and randomly reviewed by an experienced radiologist who was blind to the position of the lower limbs during MRI study.

The lumbar lordosis was measured on sagittal MR images following a previously described method [14] by calculating the angle between the superior endplate of L1 and the superior endplate of S1.

The amount of anterior translation was calculated on sagittal MR images using the posterior cortices of the cranial and caudal vertebral bodies according to a previously described method [15]. Following the method described by Taillard [16], slip percentage was calculated as the amount of anterior translation divided by the anteroposterior diameter of the top of the caudal vertebra.

Two ensure intraobserver reliability, data from two sets of measurements ($n = 35$) at two different timepoints were compared. For the angle of lumbar lordosis, the mean difference was 3.00° with a standard deviation of the difference of 0.12°. For the amount of slippage, they were 1.37 mm and 0.06 mm, respectively. The limits of agreements were within the 5% of the mean value [17].

Intervertebral disc pathology, facet joint changes and Modic type endplate changes in the listhetic segment were documented according to previous definitions [18–20].

3. Statistical analysis

The SPSS software version 22.0 (IBM Corporation, New York, USA) was used for statistical analysis. Independent samples *t* test, paired samples *t* test, one-way ANOVA, and McNemar–Bowker test were used for comparisons, where appropriate. A linear regression model was used for multivariate analysis. Correlation was examined by calculating the Pearson correlation coefficient (r). A significance level of $p \leq 0.05$ was used.

4. Results

The patients were 15 males (15%) and 85 females (85%) with a mean age of 56.48 ± 12.32 years (range: 25–80).

The listhetic level was L4–L5 in 62 cases (62%) and L5–S1 in 38 cases (38%).

Spondylolisthesis was of isthmic type in 57 patients (57%) and of degenerative type in 43 patients (43%).

Within the listhetic segments intervertebral disc pathologies were present in 13 patients, including disc protrusion in 12 cases and disc extrusion in 1 case. Facet joint changes at the involved levels were present in 36 patients. Endplate changes in the listhetic levels were documented in 59 patients, including Modic type I in 19 cases, Modic type II in 31 cases, and Modic type III in 9 cases.

Table 1
Different grades of spondylolisthesis on magnetic resonance (MR) images with flexed and straightened lower extremities.

	Grade	With straightened lower extremities		
		I	II	III
With flexed lower extremities	I	32 (59.3)	22 (40.7)	0 (0)
	II	0 (0)	44 (100)	0 (0)
	III	0 (0)	0 (0)	2 (100)

Data are shown as frequency (%).

The mean angle of lumbar lordosis was 51.65 ± 8.57° (range: 26–71) on conventional MR images (with flexed lower limbs) that increased to 57.39 ± 9.05° (range: 36–75) on MR images with straightened lower limbs (paired samples *t* test $p < 0.001$). The mean percent increase was 11.51 ± 6.47%.

An example of increased lumbar lordosis from an MR image with flexed lower limbs to the same MR image with straightened lower limbs is shown in Fig. 2.

The mean slip percentage was 25.80 ± 7.74% (range: 14.45–58.45) on conventional MR images that increased to 28.68 ± 7.93% (range: 16.20–61.55) on MR images with straightened lower limbs (paired samples *t* test $p < 0.001$). The mean percent increase was 12.60% (standard error of mean: 1.30).

An example of increased slip percentage from an MR image with flexed lower limbs to the same MR image with straightened lower limbs is shown in Fig. 3.

On the basis of conventional MRI the spondylolisthesis was grade I in 54 cases (54%), grade II in 44 cases (44%), and grade III in 2 cases (2%).

According to the results of MRI with straightened lower limbs the spondylolisthesis was grade I in 32 cases (32%), grade II in 66 cases (66%), and grade III in 2 cases (2%).

The frequency of grade II disease increased significantly with straightened lower limbs during MRI compared to that documented by conventional position (McNemar–Bowker test $p < 0.001$).

The number of patients with grade II or III disease on conventional MR images did not change after repositioning of the lower extremities (Table 1).

The mean slip percentages by two MRI methods and their percent change are set out by study variables in Table 2.

On the basis of inter-variable analysis, the mean slip percentage was significantly higher in 50-year-old and younger patients compared to that in older ones.

The mean slip percentage was also significantly higher in patients with spondylolisthesis at L5–S1 compared to that in patients with spondylolisthesis at L4–L5; as well as in patients with degenerative spondylolisthesis compared to that in patients with the isthmic subtype.

The two sexes and the patients with and without intervertebral disc pathologies, facet joint changes, or Modic type endplate changes at the involved levels were comparable in this regard.

In multivariate analysis, the level of listhesis was the only significant, independent contributor to slip severity ($B = 5.4$, $p = 0.001$). Neither age ($B = -0.59$, $p = 0.71$) nor the type of spondylolisthesis ($B = -1.75$, $p = 0.29$) played independent roles in this regard.

Individual inter-variable analysis between the two sets of MR images revealed that the mean slip percentage was significantly higher on MR images with straightened lower limbs compared to that on conventional MR images for all comparisons. The study variables did not significantly affect the slip percent change.

A significant positive correlation was found between the degree of slippage and the angle of lumbar lordosis (Pearson $r = 0.20$, $p = 0.04$).