

Degenerative Spondylolisthesis Factors at Level L4–5: MR Imaging Findings

Harry Wahyudhy Utama^a, Paulus Rahardjo^{a*}, Rosy Setiawati^a

Corresponding author, paulus.r.rahardjo@gmail.com

^aDepartment of Radiology, Faculty of Medicine, Universitas Airlangga, - Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Abstract

Introduction: Over time, the body, including the spine, undergoes anatomical and morphological changes. Magnetic resonance (MR) imaging is a good modality to analyse degenerative processes by evaluating joint deformity and fat accumulation in bone and muscle. We studied MR images from 22 patients diagnosed with spondylolisthesis at level L4-5 to characterise the factors that cause spondylolisthesis, including disc degeneration, facet joint osteoarthritis, fatty infiltration of the multifidus muscle and thickening of the ligamentum flavum.

Materials and Methods: Twenty-two patients with degenerative spondylolisthesis diagnosed by MR imaging were enrolled in this study to characterise the following factors in the degenerative spine at level L4-5: intervertebral disc, facet joint, multifidus muscle and ligamentum flavum.

Results: None of the evaluated factors were normal at level L4-5; all had degenerated to various degrees. Twelve discs (54.5%) showed a significant decrease in disc height with a hypointense signal, indicating grade IV. Fifteen cases (68.1%) showed narrowing and irregularity of the facet joint with marked osteophytes, suggesting severe joint osteoarthritis. In 11 cases (50%), fat had already infiltrated the multifidus muscles such that there was an equal amount of fat and muscle tissue, indicating grade III on the Goutallier classification. Thickening of ligamentum flavum was also observed, with maximal thickening of 6.7 mm (right) and 7.1 mm (left).

Conclusion: Our study confirms that degeneration of the intervertebral disc, facet joint osteoarthritis, multifidus muscle fatty infiltration and thickening of ligamentum flavum are present in patients with spondylolisthesis at level L4-5.

Keywords: Degenerative Spondylolisthesis; Intervertebral Disk; Facet Joint; Lumbar Multifidus; Ligamentum Flavum; MR Imaging

1. INTRODUCTION

Around the age of 40, humans start to lose their lean tissue (muscles and bones). This process has a major effect on the spine and can cause spondylolisthesis [1,2]. Spondylolisthesis caused by degenerative processes occurs mostly at level L4–5, as the greatest effects on spinal load and mobility are observed in this region [3].

The initial degenerative process in the spine is disc degeneration, which leads to settling of the motion segment and narrowing of the disc space [4]. This process causes secondary deterioration of the facets, ligaments and muscles [5]. Degeneration of intervertebral discs, facet joint arthrosis and ligamentum flavum thickening have been identified as the cause of degenerative spondylolisthesis [6]. The multifidus muscle, the function of which has a greater influence on level 4-5 than on other regions of the spine, starts to degenerate after the age of 30, causing a reduction in spine tension and losing its effective control, ultimately causing lumbar instability [8,9].

This study aims to use magnetic resonance (MR) imaging to characterise the factors that cause spondylolisthesis at level L4-5, including disc degeneration, facet joint osteoarthritis, fatty infiltration of the multifidus muscle and thickening of the ligamentum flavum.

2. MATERIALS AND METHODS

- **Study Population**

Twenty-two patients were included in this study: 7 men and 15 women between 47 and 79 years of age, with an average age of 63.18 years. The inclusion criteria were patients who were 40 years or older and had been diagnosed with lumbar spondylolisthesis with a complete spine MR imaging protocol. Exclusion criteria were patients with post spinal trauma, a congenital spine defect, spine tumour or metastatic disease.

- **Image Interpretation**

Images were evaluated on an AW VolumeShare 5 workstation from GE Healthcare. Intervertebral discs were analysed using sagittal T2-weighted images. Multifidus muscles were analysed using axial T1-weighted images. Facet joints and ligamentum flavum were analysed using axial T2-weighted

images.

- **Intervertebral discs**

Intervertebral disc degeneration was evaluated according to the Pfirrmann grading scale [10].

- **Facet joints**

Facet joints were evaluated according to the Pathria grading scale [11].

- **Multifidus muscles**

Fatty infiltration of the multifidus muscles was evaluated according to the Goutallier classification [12,13].

- **Ligamentum flavum**

Ligamentum flavum thickness was measured at the thickest area, mid of the facet joint level [14,15].

3. RESULTS

Twenty-two patients, 7 men and 15 women between 47 and 79 years of age, were included in this study, with most of the patients in the 60–69 age group (Table I).

Table I. The characteristics of the sample based on gender and age groups

| Characteristics | Samples (n=22) |
|-------------------|----------------|
| Gender | |
| Male | 7 (31.8%) |
| Female | 15 (68.1%) |
| Age Groups | |
| 40-49 | 1 (4.5%) |
| 50-59 | 5 (22.7%) |
| 60-69 | 13 (59.0%) |
| 70-79 | 3 (13.7%) |

We evaluated the spondylolisthesis at level L4-5, including disc degeneration, facet joint osteoarthritis, multifidus muscles fatty infiltration and thickening of ligamentum flavum.

All intervertebral discs analysed had degenerated to various degrees. Twelve discs (54.5%) had a significant decrease in disc height and a hypointense signal and were thus classified as Grade IV on the Pfirrmann grading scale, while eight cases (36.3%) had a collapsed disc, indicating Grade V.

No normal facet joints were observed in this study. In 15 cases (68.1%), facet joints were narrowed and irregular with marked osteophytes, suggesting severe joint osteoarthritis. There were 6 cases (27.2%) with narrowed facet joints with marked osteophytes, suggesting moderate facet joint osteoarthritis. In addition, one case showed a narrowed facet joint, suggesting mild facet joint osteoarthritis.

There was also no normal multifidus muscle found at level L4-5. In 11 cases (50%), fat had already infiltrated the multifidus muscle so that muscle and fat were present at equal amounts, indicating Grade III fatty infiltration based on the Goutallier classification, and in 8 cases (36.3%), the muscle component was still greater than that of fat, indicating Grade II fatty infiltration.

This study also found thickening of ligamentum flavum, with thickening of the right ligamentum flavum in 13 cases (59.1%), with maximal thickening of 6.7 mm, and thickening of the left ligamentum flavum in 12 cases (54.5%), with maximal thickening of 7.1 mm. All findings are summarised in Table II.

Table II. The characteristics of degenerative spondylolisthesis factors

| Factors | Frequency (%) |
|----------------------------|----------------------|
| Intervertebral Disc | |
| Grade I (normal) | 0 |
| Grade II | 0 |
| Grade III | 3 (13.6%) |
| Grade IV | 12 (54.5%) |
| Grade V | 8 (36.3%) |
| Facet Joint | |
| Grade I (Normal) | 0 |
| Grade II | 1 (4.54%) |
| Grade III | 6 (27.2%) |
| Grade IV | 15 (68.1%) |
| Multifidus muscles | |
| Grade 0 (Normal) | 0 |
| Grade I | 1 (4.54%) |
| Grade II | 8 (36.3%) |
| Grade III | 11 (50%) |
| Grade IV | 2 (9.0%) |
| Ligamentum flavum | |
| Right | |
| ≤ 3.9 mm | 9 (40.9%) |
| > 3.9 mm | 13 (59.1%) |
| maximal thickening | 6,7 mm |
| Left | |
| ≤ 3.9 mm | 10 (45.4%) |
| > 3.9 mm | 12 (54.5%) |
| maximal thickening | 7,1 mm |

4. DISCUSSION

At the age of 40, people start losing their tissue (muscles and bones) [16]. This process, called ageing or the degenerative process has a major effect on the spine [15]. All organs that maintain the spine's alignment are affected by the degenerative process, resulting in the slip of one vertebral body over the one below, or spondylolisthesis [2]. Spondylolisthesis caused by degenerative processes occurs mostly at level L4–5, as degeneration has the greatest effect on spinal loads and mobility in this region [3].

Disc degeneration starts in the first decade of life and peaks during one's thirties [17]. In this process, the nucleus pulposus and annulus fibrosus start to lose their structural integrity, resulting in structural weakness ultimately causing instability and spondylolisthesis [18]. In this study, we found no normal intervertebral discs at level L4-5 in any of the patients included; all exhibited disc degeneration to various degrees,

as described in Table II. Disc degeneration is considered as the initiating event that results in secondary deterioration of the facets, ligaments and muscles [5].

Facet joint degeneration begin as early as 15 years [19]. Degeneration in the lumbar spine and facet cartilage alter the mechanical function of the facet joint. In this study, all facet joints had already degenerated – as described in Table II, there were no normal facet joints observed. Many studies have shown that facet morphology affects the progression of degenerative spondylolisthesis [20]. Moreover, in a previous study, no facet joint degeneration was observed in the absence of disc degeneration [21].

Ligamentum flavum very important to maintain and preserve normal spine curvature [22]. Ligamentum flavum start to degenerate at the age of 20 and tend to thicken with increasing age [19,23,24]. This study found thickening of both the right (13 cases) and left ligamentum flavum (12 cases). Degeneration in the ligamentum flavum and repeated flexion-extension motion may lead to thickening of the ligamentum flavum [25].

The multifidus muscle has the strongest influence and is the last factor that holds the spine alignment specifically at level L4-5 [8]. The multifidus muscle starts to degenerate after the age of 30, and even faster after the age of 60 [24]. In this study, all multifidus muscles had been infiltrated by fat, as described in Table II. Multifidus muscle that is infiltrated by fat will lose its ability to effectively control spine tension, ultimately causing lumbar instability [9].

5. CONCLUSION

As part of the ageing process, all tissues and organs that maintain spine alignment will degenerate, causing alteration of the structural anatomy and function of the spine, resulting in degenerative spondylolisthesis. This study confirms that degeneration of the intervertebral disc, facet joint osteoarthritis, fatty infiltration of the multifidus muscle and thickening of ligamentum flavum are present in patients with spondylolisthesis at level L4-5.

ETHICS COMMITTEE APPROVAL

This study has met the ethical principles of and received approval from the Research Ethics Committee of Dr. Soetomo General Hospital, Surabaya.

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None

DISCLOSURE

The authors have no conflicts of interest to declare.

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