ASRA PAIN MEDICINE
22nd Annual Pain Medicine Meeting
November 10-11, 2023 | New Orleans, Louisiana
#ASRAFall23

Abstract: 4505

Scientific Abstracts > Chronic Pain

DYNAMIC INSTABILITY IS UNDERESTIMATED ON STANDING FLEXION-EXTENSION FILMS WHEN COMPARED TO PRONE CT IMAGING

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Introduction

Dynamic lumbar instability evaluated on flexion-extension radiographs has been a longstanding convention in the decision-making for identifying the level of axial and radicular pain and its consequent management. However, flexion-extension radiographs may underestimate the degree of lumbar spondylolisthesis, limiting the ability to characterize the appropriate vertebral level for local analgesic delivery [1]. Despite efforts to characterize dynamic instability, significant variability remains in current guidelines regarding the most appropriate imaging modalities to adequately evaluate instability [2]. We performed a retrospective study evaluating the incidence and degree of L4-5 anterior spondylolisthesis in patients with standard supine MR, standing radiographs, and prone CT, with an emphasis on the sensitivity of prone positioning to identify spondylolisthesis. Prone CT imaging was obtained during fluoroscopically-guided steroid injections. We hypothesize that positional changes will affect the degree of dynamic instability, with spondylolisthesis observed in prone position providing greater sensitivity for instability compared to standing or supine positions.

Materials and Methods

Single center retrospective cohort for individuals with single-level (L4-5) anterolisthesis between 2014 – 2022 with standing radiographs (CR), prone CT scans (CT), or supine MRI images (MRI). Patients were excluded from the study for the following: presence of lumbar hardware, patients with missing imaging modalities (either X-ray, CT or MRI), time between any modalities exceeding 13 months, no evidence of anterolisthesis, or poor quality of imaging study precluding the ability to fully visualize and assess spondylolisthesis. The study was approved by the Institutional Review Board at Mass General Brigham. Single center retrospective cohort for individuals with single-level (L4-5) anterolisthesis between 2014 – 2022 with standing radiographs (CR), prone CT scans (CT), or supine MRI images (MRI). Patients were excluded from the study for the following: presence of lumbar hardware, patients with missing imaging modalities (either X-ray, CT or MRI), time between any modalities exceeding 13 months, no evidence of anterolisthesis, or poor quality of imaging study precluding the ability to fully visualize and assess spondylolisthesis. The study was approved by the Institutional Review Board at Mass General Brigham. Sagittal translation of 2 mm, 3 mm, and 4.5 mm thresholds were used based upon previous reports [3].

Results/Case Report

The average age of patients was 73.7 ± 9.6 years old. Seventy-one females and 31 males were included. The average translation (± SD) measured were 4.9 ± 2.2 mm (CR), 2.5 ± 2.6 mm (CT), and 3.7 ± 2.6 mm (MRI) ($p < 0.001$) (Table 2). The mean difference in anterolisthesis among imaging modalities were 2.7 ± 1.8 mm between CR and CT ($p < 0.001$), 1.8 ± 1.4 mm between CR and MRI ($p < 0.001$), and 1.6 ± 1.4 mm between CT and MRI ($p = 0.252$) (Table 3). Ninety two of 102 patients (90.2%) showed greater anterolisthesis on CR compared to CT, 72 of 102 (70.6%) comparing CR to MRI, and 27 of 102 (26.5%) comparing CT to MRI.

Comparing CR with MRI, we found that 17.6% of patients exhibited > 3 mm anterior translation, whereas 38.2% patients were identified comparing CR with CT imaging, indicating a 20.6% difference in missed lumbar instability ($\chi 2$ test $p = 0.0009$, post-hoc Fisher's exact test $p = 0.0006$ between CR and CT). Only a small percentage of patients had comparable degree of instability between flexion-standing (5.9%) and extension-standing radiographs (11.8%). We identified comparable results using 2 mm and 4.5 mm thresholds (Table 3).

Discussion

Diagnostic imaging plays a significant role in the management of low back pain. Interventionalist rely on these modalities to identify the spinal level that may be contributing to pain symptomology for targeted delivery of therapeutic agents. We found that sagittal segmental instability in the prone position (2.5 ± 2.6 mm, as measured with CT during interventional procedures) exhibits the greatest reduction in anterolisthesis as compared with standing lateral X-rays (4.9 ± 2.2 mm) or supine MRI (3.7 ± 2.6 mm). Furthermore, dynamic instability occurred more frequently when comparing standing X-rays with prone CT (Table 3). In the 3 mm group, we identified a greater than 6-fold difference in detecting anterolisthesis between CR – CT (38.2%) versus CR – flexion (5.9%). This represents an underestimation of 32.3% of our patient population, consistent with a previous study [4]. We also found greater than 5-fold difference with a threshold of 4.5 mm, suggesting that standing-prone comparisons may provide more sensitivity to L4-5 segmental instability than flexion-standing imaging only.

We argue that comparing standing lateral X-rays with prone CT scans provides significant insight into patients' degree of segmental instability. As patients often undergo interventional procedures for back pain, CT imaging obtained during these patient encounters provides significant diagnostic utility without the need for additional imaging. Moreover, prone positioning reduces patient effort required with flexion-extension stress views, thereby minimizing measurement error.

References

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Disclosures

No

Tables / Images

Table 1 – Demographic information of study population

	Male	Female	Total (SD)
Number	31 (30.4%)	71 (69.6%)	102
Age	74.5 (9.8)	71.8 (9.5)	73.7 (9.7)
BMI	31.2 (5.1)	30.8 (6.1)	30.9 (5.8)
Race			
Asian	1 (3.2%)	2 (28%)	3 (2.9%)
Black	2 (6.5%)	9 (12.7%)	11 (10.8%)
Hispanic	0	5 (7.0%)	5 (4.9%)
White	28 (90.3%)	55 (77.4%)	83 (81.4%)

Table 2 – Average translations standing, prone, supine, and flexion-extension

	Mean mm (SD)
X-ray	
Standing	4.9 (2.2)
Flexion	4.1 (1.9)
Extension	3.4 (2.0)
Prone (CT)	2.5 (2.6)
Supine (MRI)	3.7 (2.6)

Table 3 – Average difference in translation among positions

	Mean mm (SD)	Patients ≥ 2 mm translation (%)	Patients ≥ 3 mm translation (%)	Patients ≥ 4.5 mm translation (%)
CR-CT	2.7 (1.8)	57 (55.9)	39 (38.2)	16 (15.7)
CR-MRI	1.8 (1.4)	29 (28.4)	18 (17.6)	4 (3.9)
CT-MRI	1.6 (1.4)	23 (22.5)	16 (15.7)	6 (5.9)
Flex-CR	1.3 (1.4)	6 (17.6)	2 (5.9)	1 (2.9)
Ext-CR	1.7 (1.6)	9 (26.5)	4 (11.8)	1 (2.9)
Flex-Ext	0.9 (0.8)	5 (14.7)	0 (0)	0 (0)