

Dynamic Radiographs Not Always Essential in Diagnosis of Lumbar Spinal Instability

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Rec Date: July 16, 2018; Acc Date: August 20, 2018; Pub Date: August 24, 2018

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Abstract

Objective: Dynamic radiographs are widely used to assess radiological spinal instability. The authors aim to compare the sensitivity of dynamic radiographs versus spontaneous reduction seen on magnetic resonance imaging when compared to a standing lateral radiograph in diagnosing instability.

Materials and Methods: This study is a retrospective review of 75 patients from a single center with suspected clinical lumbar spinal instability presenting with back and/or leg pain and had undergone a magnetic resonance imaging of their lumbosacral spine as well as a lumbar radiograph series. The authors compared the criterion sensitivity (in accordance to Posner criteria) of dynamic radiographs versus magnetic resonance imaging. Pearson's chi-square test was used to determine statistical significance.

Results: The Posner criteria was satisfied in 45/75 patients (60%) using dynamic radiographs as compared to 32/75 patients (42.6%) when using spontaneous reduction seen on magnetic resonance imaging. This was statistically significant ($p < 0.01$). However, we noted that 29/45 (64.4%) patients with instability diagnosed on dynamic radiographs also had it diagnosed on spontaneous reduction.

Conclusion: Posner criteria when applied to spontaneous reduction seen on magnetic resonance imaging has a specificity of 90% and positive predictive value of 90.63%, assuming that satisfaction of Posner criteria on dynamic radiographs indicates true instability. The authors advocate the use of Posner criteria applied to spontaneous reduction to assess for spinal instability. Failure to satisfy the Posner criteria on spontaneous reduction should then prompt the use of a more sensitive modality such as dynamic radiographs.

Keywords: Spinal instability; Lumbar instability; Spondylolisthesis; Dynamic radiographs; Flexion extension x-rays; Posner criteria

Introduction

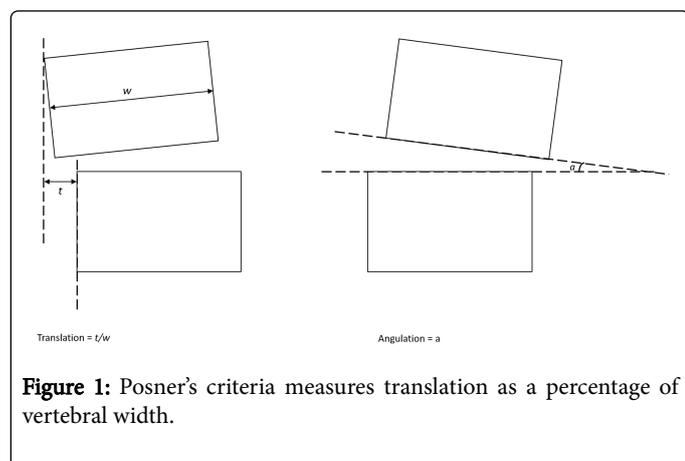
Lumbar spinal instability is a common cause of lower back and/or leg pain [1,2]. This condition is of significant clinical importance as its presence in patients with lower back and/or leg pain serves as a criterion for spinal fusion over mere decompression [3-8]. Selecting patients with spinal instability for spinal fusion surgery is related with better outcomes [5,7,8]. The American Association of Orthopedic Surgeons defines spinal instability as 'an abnormal response to applied loads, characterized by movement in the motion segment beyond normal constraints' [9]. Knutsson was the first to demonstrate abnormal motion of the vertebrae upon extreme flexion of the spine [10]. He observed parallel displacement as well as abnormal tilting movements of the vertebrae, which may be termed translation as well as angulation respectively. Dupuis et al. suggested a method to establish radiological instability with the use of standing dynamic radiographs [11], measuring translation as a forward or backward displacement of a vertebral body with respect to the vertebral body immediately inferior to it and angulation as the angle measured at the vertebral end plates of the two adjacent vertebrae (Figure 1). This

method has been used over the years by different authors who have then come up with different thresholds [12-14] to diagnose radiological instability.

Posner's criteria measures translation as a percentage of vertebral width (Figure 1) to avoid inaccuracies from magnification [15] and is commonly used. The upper limits are as follows 'anterior translation greater than 8% (L1-L5) or greater than 6% (L5-S1), posterior translation greater than 9% (L1-S1), angulation in flexion greater than -9° (L1-L5) or greater than 1° (L5-S1) [15]. Yone et al. found the Posner criteria to be useful in selecting patients for spinal fusion surgery [6]. In their study, excellent improvement of symptoms and return of function resulted from posterolateral spinal fusion with instrumentation compared to laminotomy alone for patients with spinal instability diagnosed using the Posner criteria.

Other radiological modalities such as magnetic resonance imaging and computed tomography have also been used to aid the diagnosis of instability [1]. In 2012, Chung and co-authors described the phenomenon of spontaneous reduction of the listhetic segment on supine magnetic resonance imaging when compared to a standing lateral lumbar radiograph [16]. This was theorized to be due to the elimination of physiological loading in the supine position compared to the standing position. In a retrospective review of 137 patients, they

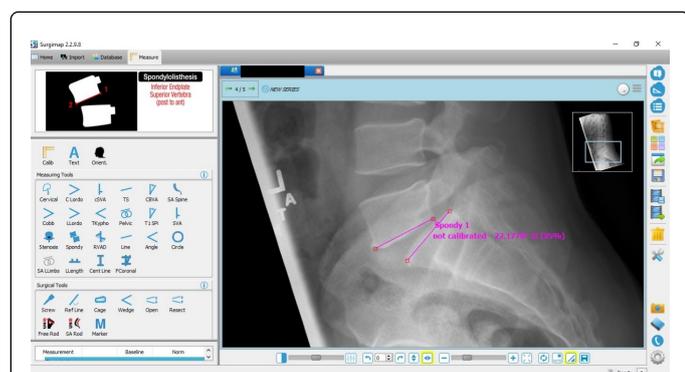
found the degree of spontaneous reduction to be closely related to instability [16].



We applied the Posner criteria to the spontaneous reduction phenomenon as described by Chung to find out the criterion sensitivity. We then compared the sensitivity to that of standing dynamic radiographs.

Materials and Methods

This is a retrospective study of 100 consecutive patients who underwent a supine magnetic resonance scan of the lumbosacral spine, standing anterior-posterior, lateral as well as dynamic lumbar radiographs. They all had suspected clinical lumbar instability and presented with lower back and/or leg pain. After excluding patients with a history of trauma, severe kyphoscoliosis, previous surgical instrumentation of the spine and/or poor quality radiographs, we analysed the images of the remaining 75 patients.



We utilised the radiological software Surgimap® (© 2016 Nemaris, Inc™) in our analysis of the images. Surgimap® is software that allows users to import images and measure various clinical parameters such as Cobb's angle in scoliosis as well as degree of lordosis and kyphosis by selecting appropriate anatomical landmarks. The 'Spondylolisthesis' function in Surgimap® measures percentage translation and degree angulation in accordance to the Dupuis method [11] (Figure 2). Two observers were trained by one Orthopedic surgeon familiar with

Surgimap® and underwent a pilot test with 10 patients. Both observers then analysed the images independently and analysed not more than 10 patients at one seating to prevent mistakes from observer fatigue. We ran a bivariate analysis to find out the degree of inter observer variability.

Criterion sensitivity was determined by the satisfaction of the Posner criteria. Pearson's Chi-square test was used for significance testing of the difference in sensitivities of dynamic radiographs and spontaneous reduction in picking up instability. Bivariate correlation of the observers' measured values of degree angulation and percentage translation on both modalities was analysed to determine inter observer variability.

Results

The average age was 59.7 years old (28-86). There were 42 male and 33 female subjects. The commonest levels of spondylolisthesis were L4/5 (34/75, 45.3%) and L5/S1 (33/75, 44%). The inter observer variability was low as reflected by a high correlation between the observers' measured degree angulation on dynamic radiographs ($r=0.939$, $p<0.01$), observers' measured percentage translation on dynamic radiographs ($r=0.791$, $p<0.01$), observers' measured degree angulation on spontaneous reduction ($r=0.755$, $p<0.01$) and observers' measured percentage translation on spontaneous reduction ($r=0.796$, $p<0.01$).

The Posner criteria was satisfied in 45/75 patients (60%) using dynamic radiographs as compared to 32/75 patients (42.6%) when using spontaneous reduction seen on magnetic resonance imaging. This was statistically significant ($p<0.01$). However, we noted that 29/45 (64.4%) patients with instability diagnosed on dynamic radiographs also had it diagnosed on spontaneous reduction. There also existed 3/30 (10%) of patients who had instability diagnosed on spontaneous reduction but not on dynamic radiographs.

Assuming that satisfaction of the Posner criteria on dynamic radiographs indicates true instability, the Posner criteria when applied to spontaneous reduction seen on magnetic resonance imaging when compared to a standing lateral lumbar radiograph yields a specificity of 90%, 95% CI (72.32, 97.38), sensitivity of 64.44%, 95% CI (48.73, 77.71), positive predictive value of 90.63%, 95% CI (73.83, 97.55) and negative predictive value of 62.79%, 95% CI (46.72, 76.61).

Discussion

Many authors have proposed different definitions of and diagnostic criteria for instability over the years. Panjabi suggested a biomechanical definition of 'a loss of motion segment stiffness, such that force application to that motion segment produces abnormally great motion compared to that of a normal spine' [17]. Frymoyer then proposed a widely accepted clinical criteria of instability as 'a condition where there is loss of spinal stiffness, such that normally tolerated external loads will result in pain, deformity, or put neurological structures at risk' [18] for greater clinical relevance. Kotilainen proposed yet another clinical criteria which diagnoses the presence of instability 'if a full return from the bent position fails because of a sudden attack of low back pain (ie. instability catch), if a patient is unable to get a raised, straightened leg to move down and suddenly drops the leg due to a sharp pain in the low back (ie. painful catch), and/or if a patient feels anxiety resulting from a sensation of collapse of the low back because of a sudden attack of back pain during movement

(ie. apprehension)' [19] but this criteria has not been rigorously evaluated [9].

Despite numerous efforts, there is currently no gold standard in the radiological diagnosis of spinal instability due to reasons such as a lack of standardization of the method in which dynamic radiographs are performed. Many alternatives to standing dynamic radiographs suggested by Dupuis have been discussed, such as traction-compression [20], supine [21], supine-prone [22] and slump-sitting dynamic radiographs. Each method has its proposed advantages over the conventional standing dynamic radiographs but none has been globally accepted and practiced. It has also been argued that back pain and paraspinal muscle spasm may reduce the motion of the lumbosacral segment and hence not accurately reflect the true degree of instability seen on dynamic radiographs [11,20].

In view of the potential pitfalls of dynamic radiographs, other imaging modalities such as magnetic resonance imaging are used to aid the diagnosis of spinal instability. Magnetic resonance imaging often prove useful in the assessment of a patient with suspected spinal pathology presenting with persistent or recurrent lower back and/or leg pain refractory to conservative management. It is generally accepted to be the most accurate imaging method for diagnosing degenerative changes of the spine [1] and is often used to identify central or foraminal stenosis [16]. It is also a favoured imaging modality due to its high contrast and spatial resolution and lack of ionizing radiation [23]. Chung and co-authors described the phenomenon of spontaneous reduction of the lumbosacral segment seen on magnetic resonance imaging when compared to a standing lateral lumbar radiograph [16]. In a retrospective review of 137 patients, Chung found a statistically significant correlation between spontaneous reduction and the degree of instability.

Within the confines of this study, the Posner criteria are more sensitive when applied to dynamic radiographs. However, when applied to spontaneous reduction, it yields a specificity of 90% and a positive predictive value of 90.63%. This may prove to be an effective way in assessing radiological instability for patients with suspected clinical instability who have already had a lateral lumbar radiograph and magnetic resonance imaging performed as part of their clinical workup.

Satisfaction of the Posner criteria on spontaneous reduction may save the need for extra dynamic radiographs and its associated costs and exposure to radiation. The estimated effective radiation dosage a patient is exposed to from an anterior-posterior, lateral and dynamic lumbar radiograph is 1.2, 1.0 and 2.2 milli sieverts (mSv) respectively [24]. This means that an exclusion of dynamic views will prevent the patient from exposure to roughly 3 months of natural background radiation.

With a low sensitivity of 64.44% and negative predictive value of 62.79%, a failure to satisfy Posner criteria when applied to spontaneous reduction should not rule out spinal instability. This may then be an indication for further investigations with higher sensitivity such as dynamic radiographs.

Conclusion

It is important to have a reliable imaging and measurement method and specific diagnostic criteria to establish instability due to its presence serving as a criterion for spinal fusion over mere decompression. The methods in which supine magnetic resonance

imaging and lateral lumbar radiographs are performed are more consistent compared to that of dynamic radiographs. With a specificity of 90% and a positive predictive value of 90.63%, the authors advocate the use of Posner criteria applied to spontaneous reduction on supine magnetic resonance imaging when compared to a standing lateral lumbar radiograph should these modalities already be available. Failure to satisfy the Posner criteria on spontaneous reduction should then prompt the use of a more sensitive modality such as dynamic radiographs.

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This article was originally published in a special issue, entitled: "**Minimally Invasive Spine Surgery -II**", Edited by Anthony T. Yeung, M.D. Clinical professor, University of New Mexico School of Medicine Associate Desert Institute for Spine Care, Phoenix, Arizona Executive director International Intradiscal therapy Society Phoenix, Arizona