SVOA Orthopaedics

ScienceVolks Open Access

Research Article

What is the Ideal Zoom for Digital Lumbosacral Spine Radiographs to Detect Mild Instability?

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***Received:** September 12, 2021* ***Published:** October 05, 2021*

Abstract

Background: Often, lumbar spine radiographs are digitally printed in zoom [magnification] percentages smaller than 100% to cut down on the costs of a larger film! This might however, compromise cursory visual assessment of instability, particularly in low grade spondylolistheses. Present study aimed to assess accuracy of cursory visual assessment for radiological lumbar instability with varying zoom [magnification] percentages in digital radiographs in spondylolistheses <grade II.

Materials and Methods: Prospective trial carried out after IRB approval. Patients with complaints of low backache with/ without radiculopathy included. Patients with spondylolistheses> grade I, infections, trauma excluded. Pairs of flexion-extension radiographs of lumbar spine of all included patients printed in 25%, 50%, 75% and 100% zoom [magnification] on digital radiographic films. Each week, a set of radiographs of one zoom [magnification] level of every patient sent to practicing spine surgeons. Objective measurement of instability done by another observer using White and Panjabi's criteria.

Results: Nineteen patients included. Ten practicing spine surgeons participated. Accuracy of assessment of instability was 53.4%[range:42%-74%], 54.8% [37%-68%], 60% [48%-68%] and 66.5% [48%-79%] in 25%, 50%, 75% and 100% zoom [magnification] percentages, respectively. This difference was statistically significant [p=0.01]. There was a decreasing trend of false positive values too, as the zoom [magnification] percentage increased [p=0.0066].

Conclusion: Though printing films in zoom [magnification] percentages less than 100% may cut down costs, it compromises cursory screening for lumbar radiological instability. This would be particularly relevant in high-volume surgical units wherein detailed objective assessment for every single patient may be impractical.

***Keywords:** lumbar spine, instability, radiological instability, dynamic radiographs,*

Introduction

Spinal instability is one of the most important causes of low back pain. Although there is some controversy regarding its definition, it is most widely accepted that loss of normal pattern of spinal motion causes back pain and/or neurologic dysfunction and would constitute the clinical presentation of spinal instability[1].

Lumbar spine radiographs taken in flexion and extension, often referred to as dynamic radiographs, are the most routine investigations to detect instability in the spine[2]. Digital radiography has allowed printing or viewing of these radiographs in varying zoom [magnification] percentages. Often, these are printed in zoom [magnification] percentages smaller than 100%, i.e. less than 1:1 proportion, in order to cut down on the costs of a larger radiographic film. However, objective criteria for instability in terms of abnormal translation of one vertebra over the other have been largely defined for 100% zoom [magnification][1]. Consequently, there would be a propensity for error in a cursory visual assessment to identify instability in a radiograph viewed at zoom [magnification] percentages other than 100%. This would be particularly pertinent in low grade spondylolistheses.

The present study was carried out to assess whether the accuracy of cursory visual assessment for radiological lumbar spinal instability in the form of abnormal translation and/ or angulation in dynamic radiographs tends to vary with varying levels of zoom [magnification] percentages in digital radiographs in spondylolistheses not exceeding Meyerding grade I.

Materials and Methods

After due IRB approval, patients presenting with complaints of low backache with or without radiculopathy were prospectively included in this study. Patients were included in the study from 1st December 2016 till 30th November 2017. Patients with spondylolistheses greater than grade I, infections, trauma, as well as postoperative patients were excluded.

Lateral radiographs were taken in maximum flexion and extension of lumbar spine[3]. To perform flexion radiograph, the patient was made to lie down in the lateral decubitus position on radiographic table with hands placed over the head; hips and knees flexed with an attempt to maximally actively bend the trunk anteriorly as far as possible to bring the knee as close as possible to anterior chest. To perform extension radiograph, patient was instructed to perform maximal active extension with hips in extension.

Practicing spine surgeons, with minimum five years of clinical practice as independent spine surgeons were identified to participate in the study. Pairs of flexion-extension radiographs of lumbar spine of all included patients were printed in 25%, 50%, 75% and 100% zoom [magnification] [100% corresponding to 1:1 proportion] on digital radiographic films. These sets were then sent to the participants. Each week, a set of radiographs belonging to only one zoom [magnification] level was sent. Names of patients were masked in the radiographs. A single set of flexion- extension radiograph belonging to a single patient was given a numbered code and these were randomized every week. The participants examined these radiographs in their office rooms.

Objective measurement of instability was done independently by another observer using White and Panjabi's criteria to validate the cursory assessments [table 1][1]. Measurements of sagittal plane translation were done according to the classic method described by White and Panjabi, by drawing tangents along the posterior vertebral body lines of involved vertebrae and measuring the shift of cranial vertebra over caudal one and thereafter, calculating the difference in this measurement between flexion and extension radiographs [Fig 1]. Similarly, sagittal plane rotation too was measured by calculating the angle between tangents drawn along inferior endplate of cranial vertebra and superior endplate of caudal vertebra and thereafter, calculating the difference in this measurement between flexion and extension radiographs [Fig 2]. These measurements were made on 100% zoom [magnification] radiographs.

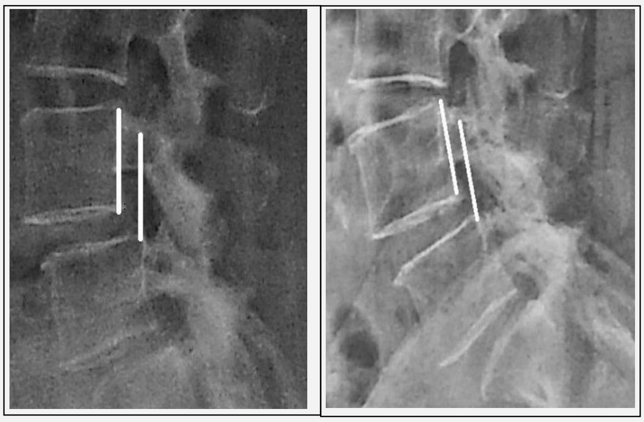

Figure 1: *Assessment of sagittal translation.*
1A: *Flexion,* ***1B:*** *Extension*

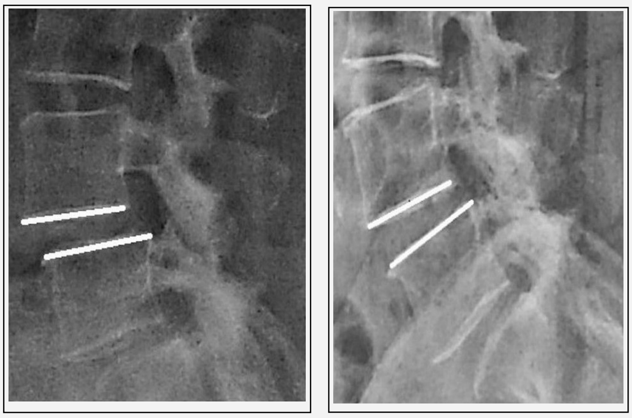

Figure 2: *Assessment of sagittal plane rotation.*
2A: *Flexion,* ***2B:*** *Extension*

Table 1

Sagittal plane translation	>4.5mm or 15% of the anteroposterior depth of cranial vertebra
Sagittal plane rotation	>15^0 at L1-2, L2-3 or L3-4
	>20^0 at L4-5
	>25^0 at L5-S1

Statistical analysis was done using software: Graphpad Instat, version 3.10. Data following Gaussian distribution was presented as mean with standard deviation and analysed by parametric tests. Data following non-Gaussian distribution was presented as median with range in parentheses and analysed by nonparametric tests. Significance was set at two-tailed $p<0.05$. Statistical trend was tested by repeated measures ANOVA.

Results

Nineteen patients were included in the study. There were eight males and eleven females. Mean age was 57.63years [range: 42-79years]. Ten practicing spine surgeons participated in the study. Objective assessment by the independent observer as per White and Panjabi's criteria revealed instability in eight of the nineteen patients [Table 2].

Table 2

Serial no. of patient	Level	Difference between flexion and extension views		Stability
		Sagittal Plane Translation in millimeters	Sagittal Plane Rotation in Degrees	
1	L4-5	2	2	Stable
2	L4-5	5*	11	Unstable
3	L3-4	6*	16	Unstable
4	L4-5	1.5	2	Stable
5	L5-S1	3	7	Stable
6	L4-5	4	5	Stable
7	L3-4	5*	2	Unstable
8	L2-3	5*	3	Unstable
9	L4-5	5*	4	Unstable
10	L4-5	1	2	Stable
11	L4-5	0.5	2	Stable
12	L4-5	1.5	9	Stable
13	L4-5	1	8	Stable
14	L5-S1	5*	17	Unstable
15	L4-5	2.5	11	Stable
16	L4-5	1	5	Stable
17	L4-5	3	11	Stable
18	L5-S1	2	26*	Unstable
19	L4-5	5*	10	Unstable
* indicates instability as per White and Panjabi's criteria				

Accuracy of assessment of instability was 53.4% [range: 42%-74%], 54.8% [37%-68%], 60% [48%-68%] and 66.5% [48%-79%] in 25%, 50%, 75% and 100% zoom [magnification] percentages, respectively [Table 3]. This difference was found to be statistically significant by repeated measures ANOVA [p=0.0077]. This indicated that the accuracy increased with increasing zoom [magnification] percentages. Individually comparing various zoom [magnification] percentages, there was a statistically significant difference in the accuracy between 25% and 100% [p<0.01], as well as between 50% and 100% [p<0.05].

Analysis was done for the inaccurate assessments in various zoom [magnification] percentages. False positive and false negative data was filtered out [Table 3]. There was a decreasing trend of false positive values as the zoom [magnification] percentage increased [p=0.0066, by repeated measures ANOVA]. Individually comparing various zoom [magnification] percentages, there was a statistically significant difference in the false positive values between 25% and 100% [p<0.01], as well as between 50% and 100% [p<0.05]. However, no statistically significant trend was noted for false negative values as the zoom [magnification] percentage increased [p=0.2, by repeated measures ANOVA]. Interobserver agreement was highest in 100% and the least in 25% zoom [magnification] group [with mean kappa coefficient being 47.8±18.02% and 37.6±21.36%, respectively].

Table 3

	Overall accuracy [mean with range in parentheses]	False positive observations [mean with range in parentheses]	False negative observations [mean with range in parentheses]
25% zoom	53.4% [42-74%] 10.1 of 19 patients [8-14 of 19]	31.58% [15.79-42.11%] 6 of 19 patients [3-8 of 19]	14.74% [10.53-21.05%] 2.8 of 19 patients [2-4 of 19]
50% zoom	54.8% [37-68%] 10.4 of 19 patients [7-13 of 19]	28.95% [10.53-47.37%] 5.5 of 19 patients [2-9 of 19]	16.32% [10.53-21.05%] 3.1 of 19 patients [2-4 of 19]
75% zoom	60% [48-68%] 11.4 of 19 patients [9-13 of 19]	24.21% [15.79-36.84%] 4.6 of 19 patients [3-7 of 19]	13.16% [10.53-21.05%] 2.5 of 19 patients [2-4 of 19]
100% zoom	66.5% [48-79%] 12.6 of 19 patients [9-15 of 19]	17.9% [5.26-31.58%] 3.4 of 19 patients [1-6 of 19]	15.79% [10.53-21.05%] 3 of 19 patients [2-4 of 19]

Discussion

Out of more than two hundred conditions studied in the Global Burden of Disease 2010 Study, low back pain ranked highest in terms of disability and sixth in terms of overall burden[4].This leads to an increasing need for accurate diagnosis of etiology of low backache. As mentioned, spinal instability is an important etiology that needs to be ruled out in such a scenario.

There have been multiple methodologies and modalities for diagnosing spinal instability. Plain radiograph findings of relative angulation and translation, traction spurs and vacuum phenomenon have been suggested as indicative of instability[5]. CT [computed tomography] scanning may demonstrate facet tropism and vacuum phenomenon, indicative of instability[6]. MRI [magnetic resonance imaging] may also demonstrate instability in the form of endplate changes or presence of facet fluid[7]. Among all these various options, dynamic radiography remains the most popular method to detect lumbar spinal instability[8].

There have been various methods of dynamic radiography too. Use of traction-compression films in the upright posture as well as upright flexion versus prone traction as also supine and prone radiographs are the different methods that have been recommended by various workers[9-11]. However, the simplicity, low expense, and pervasive availability of functional flexion-extension radiography, also referred to as 'dynamic radiography' makes it the most thoroughly studied and the most widely used method in the imaging diagnosis of lumbar intervertebral instability[2]. There also exists diverse opinion in terms of the position in which to take dynamic radiographs; standing versus lateral decubitus position. Though standing radiographs in flexion and extension seem popular, Wood KB et al conducted a study on fifty consecutive adult patients with spondylolisthesis to ascertain this[3]. They carried out radiographs in both, standing and lateral decubitus position. Based on this study, they recommended that flexion-extension radiographs should be obtained in the lateral decubitus position than in the standing position so as to maximize motion at lumbar spine to detect instability. Hence, flexion-extension radiography in the lateral decubitus position was chosen as an indicator of instability in the present study.

In an analysis of Swedish national and regional register data, Jonsson E et al stated that the mean societal cost per episode of low back pain was estimated at €6,466; of which 74% was constituted by indirect costs and only half of the remaining 26% were related to hospital inpatient care[12]. Needless to say, investigations to rule out instability, a prominent cause of low back pain would contribute to these expenses. There exist different radiographic film dimensions for printing digital radiographs. The difference between the smallest [8inches x 10inches] and largest film [14inches x 17inches] is approximately USD2.5-3. This difference becomes pertinent in lower socioeconomic strata as well as in populations with poor health insurance cover. This fuels the need to print digital radiographs in zoom [magnification] percentages less than 100%, i.e. less than 1:1 proportion. This brings into question the accuracy of cursory visual evaluation for spinal instability in dynamic radiographs printed or viewed in varying zoom [magnification] percentages. This aspect of varying zoom [magnification] percentages is pertinent even in healthcare setups where radiographs are not printed and are just visualized on the computer monitor. To the best of authors' knowledge, there does not exist any literature to assess variations in accuracy of cursory visual evaluation for spinal instability in dynamic radiographs printed or viewed in varying zoom [magnification] percentages. Hence the present study was done to address this lacuna in literature.

Patients with low backache with spondylolistheses not exceeding Meyerding grade I were included in the present study. Dynamic radiographs printed in 25%, 50%, 75% and 100% zoom [magnification] percentages 100% corresponding to 1:1 proportion] were sent at weekly intervals to ten different spine surgeons to assess variability in assessment of instability based on varying zoom [magnification] percentages. The results showed that accuracy showed a statistically significant increasing trend with increasing zoom [magnification] percentages. Particularly notable was the significantly higher likelihood of false positive assessments for instability in lower zoom [magnification] percentages, greatly increasing the likelihood for unwarranted further investigations with the possibility of even unwarranted surgeries too in some instances. Also, the highest accuracy noted in 100% zoom [magnification] [66.5%] was also not foolproof. This would mean that a cursory visual assessment of a 100% zoom [magnification] may be used only as a screening tool and further validation of this cursory assessment should be done by objective assessment.

An arguable limitation of the present study is the radiological criteria to define lumbar spinal instability. Though White and Panjabi classified patients with >4.5mm translation on dynamic radiographs as unstable, Boden SD and Wiesel SW proposed >3mm translation[1, 13]. The authors of the present study however, contend that the results of the present study would be valid irrespective of the radiological criteria adopted for identifying instability. Also, clinical instability identification goes beyond mere assessment of radiographs in flexion and extension. However, the authors have made an attempt in the present study to analyse the scientific and practical aspects of using flexion- extension radiographs as one of the many parameters that go into defining a spine as "unstable". A relatively small sample size seems to be another obvious limitation of the present study. Despite these limitations, the results of this study have a far-reaching implication in today's era of healthcare that aims to rationalize health care costs and at the same time, optimise outcomes. To the best of authors' knowledge, the present study happens to be the first of its kind to throw light on this topic of day-to-day importance.

To conclude, though printing films in zoom [magnification] percentages less than 100% may cut down on costs, it tends to significantly compromise cursory screening for lumbar radiological instability. This would be particularly relevant in high-volume surgical units wherein detailed objective assessment for every single patient may not be possible. Even after initial screening of films at 100% zoom [magnification], it would be essential to validate the same with accurate assessment for instability.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

The authors would like to acknowledge the help of colleague spine surgeons who squeezed out time from their busy schedule to participate in this study in terms of assessing the instability in various zoom percentages at weekly intervals. These surgeons include Dr. Bushan Joseph, Dr. NC Prakash, Dr. Thomas Kishen, Dr. Rajan Babu, Dr. Bharath Sarkar, Dr. Mahesh Bijjawara, Dr. Gowrishankar, Dr. Vijay Kamath and Dr. Suman.

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Citation: Pithwa YK, Sureja KB, Meka RB. "What is the Ideal Zoom for Digital Lumbosacral Spine Radiographs to Detect Mild Instability? ". SVOA Orthopaedics 1:1 (2021) Pages 28-33.