



Patient and radiographer assessment of slump sitting flexion compared to conventional standing forward bending flexion

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Background: A comparative survey from patients and radiographers of the new slump sitting flexion posture and the conventional standing forward bending posture. This study was performed to compare the technical and logistical aspects of the slump sitting versus the forward bending posture. Slump sitting flexes the lumbar spine more than the forward bending and increases the diagnosis rate of sagittal spinal instability up to 40% depending on the diagnostic criteria used. This should not come at the expense of patient safety and comfort nor burden the radiographers.

Methods: Sixty patients were recruited from a single tertiary spine centre. Patients were block randomised into two groups with either the forward bending or the slump sitting being performed first. Feedback was obtained through self-administered questionnaires from patients regarding perceived safety, convenience and comfort, plus from radiographers regarding the imaging process, proxy measures of radiographer ability and scan difficulty.

Results: There was no significant difference between the baseline characteristics in both groups. Majority (63%) of patients preferred slump sitting and felt that forward bending caused pain ($P=0.025$). Overall, slump sitting was equivalent in comfort, perceived safety and ease to forward bending. Despite requiring more logistics ($P=0.031$), more effort to set up ($P=0.002$) and explain ($P=0.012$), the majority of radiographers (83%) preferred slump sitting. This method was felt to be less dangerous ($P=0.015$) and easier to maintain ($P<0.001$).

Conclusions: This study showed that the superiority of slump sitting in allowing more lumbar flexion compared to the forward bending comes with patient safety or comfort. The technical demands of the learning curve can be offset with training. As such, slump sitting flexion views should be adopted as the standardized method for assessing spinal instability.

Keywords: Lumbar spine; spondylolisthesis; dynamic; flexion; instability; questionnaires; slump sitting; X-rays

Submitted Nov 23, 2017. Accepted for publication May 24, 2018.

doi: 10.21037/jss.2018.09.07

View this article at: <http://dx.doi.org/10.21037/jss.2018.09.07>

Introduction

Segmental instability of the spine in the sagittal plane is a poorly-defined entity, due to the lack of standardisation in performing lumbar flexion and extension X-rays

(1-4), and the absence of consensus diagnostic criteria (5-9). Many surgeons thus plan their surgery based on what they perceive to be segmental instability (10-13), when deciding between neural decompression alone and decompression

with fusion.

The authors of this paper believe that current widely-practised methods of performing flexion-extension X-rays are suboptimal and may lead to an under-diagnosis of this condition. Patients who are unable to stand, have difficulties balancing themselves in forward flexion, who have tight hamstrings or lower limb abnormalities may be particularly at risk. In a previous study comparing slump-sitting and conventional standing forward bending methods, the former proved to be much better in stressing the lumbar spine both globally and in each individual lumbar vertebral segment (1,14). It increases the diagnosis rate of sagittal spinal instability up to 40% depending on the diagnostic criteria used (1). The increased sensitivity of this method in detecting lumbar spine instability hence serves as a good starting point for future studies aimed at establishing diagnostic criteria for segmental instability to achieve a more universal definition. This would subsequently allow us to further stratify patients according to the degree of instability and identify those who would truly benefit from fusion surgery.

In addition to its diagnostic utility, several other factors need to be considered before a radiography posture can be accepted as the 'gold standard'. It should also be safe (15), precise (16), easily reproducible (17) for the radiographers as well as comfortably achievable by the patient (15). This study aims to explore the qualitative aspects the slump sitting method of obtaining flexion-extension radiographs compared to the conventional standing forward bending method from both the radiographer and the patient perspective. We hypothesised that in addition to being diagnostically superior, the slump sitting method would be favoured by both radiographers and patients.

Methods

This study was performed concurrently with our previous study comparing the diagnostic ability of both methods—the recruitment criteria and study methodology have been previously described (1). In that study, 60 consecutive patients were recruited and randomly assigned into two groups. The first group were those who had flexion X-rays taken using the new (slump sitting) method first, followed by the conventional (standing forward bend) method; while the second group were those who had X-rays taken using the conventional method first, followed by the new method. Flexion angles were compared between both groups for the entire lumbar spine and for each segmental levels. Vertebral

translation were also compared for each segmental levels.

In this study, we distributed questionnaires to all the same patients undergoing both methods of flexion-extension X-rays, as well as the radiographers obtaining them. The National Domain-Specific Ethics Committee approval was obtained prior to study commencement, and written informed consent was taken for all subjects. There was no funding required for this study, and there were no potential conflicts of interests.

A pilot of 10 patients was used to develop the questionnaire tool prior to the commencement of the study. Aspects of positioning assessed by the questionnaire include the safety, reliability and technical challenges for the radiographers, as well as comfort for the patients. Qualitative feedback was also obtained using the questionnaires.

In the patient questionnaire, pictorial representations of the postures were included in the questionnaire leaflets for ease of reference. Dichotomous questions were used to assess each posture separately, and then patients were asked to pick their favoured posture. A copy of this questionnaire is shown in *Figure S1*.

For the radiographer questionnaire, responses were obtained in the form of a Likert-type scale from 1 to 5. Additional information including the number of attempts required to obtain satisfactory radiographs and the amount of time taken to complete the study were also collected as a proxy measure of reliability and convenience. A copy of this questionnaire is shown in *Figure S2*.

All questionnaires were self-administered. Radiographer questionnaires were in English and patient questionnaires were in both English and Mandarin. Ten patients spoke only Chinese dialects and two patients spoke only Malay, requiring translations by a clinic assistant. All questionnaires were distributed after obtaining all required X-rays. Both the patients' and the radiographers' questionnaires were collected by a study administrator for storage until the end of the study when the data was collated. A total of eight radiographers provided feedback for all 60 patients involved in the study.

Of the 60 patients who participated in the study, only 52 returned completed questionnaires initially. Eight who did not complete the questionnaires due to logistical errors were revisited and completed via telephone interview. Data from all questionnaires were included in the final analysis.

Statistical analysis

All collected data was tabulated using Microsoft Excel 2013

Table 1 Summary of patient questionnaire responses

Question	Standing forward bending method [%]	Slump sitting method [%]	P
Patient's preference	24 [37]	36 [63]	0.044
The posture was comfortable	40 [67]	45 [75]	0.422
The posture caused you pain	23 [38]	11 [18]	0.025
That posture was difficult to achieve	9 [15]	8 [13]	1.000
That posture was difficult to maintain	16 [27]	13 [22]	0.670
The posture was dangerous	9 [15]	2 [3]	0.054
There are issues with the time taken	31 [52]	28 [47]	0.715
I do not mind performing this posture again	36 [60]	41 [68]	0.447

Table 2 Qualitative comments from patients with regard to the methods used to obtain radiographs

Patient	Comments
Patient 12	I was shaking when performing the forward bending(conventional) method due to my weak legs, while the slump sitting (new) method was slightly better as the knees were bent
Patient 23	Not too long in the slump sitting(new) posture as it will cause pain
Patient 29	If I was still having back pain, this slump sitting (new) method will be difficult

(version 15.0) and analysed using International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS version 23.0).

Baseline characteristics of subjects in both groups were compared using Chi-squared tests for binomial data and unpaired t-tests for continuous parametric data to identify any significant differences that may have occurred due to chance during block randomization step (*Table 1*). Parameters evaluated include the patients' age, gender, American Society for Anaesthesiologist (ASA) grade, presence and severity of back or leg pain, duration of each pain, presence of paravertebral muscle tenderness, Schober's test, hamstring tightness and Beighton's ligament laxity score. These parameters were analysed as they can affect the patients' choice of X-ray method.

The questionnaire answers provided by the patients were tabulated as paired binary data. Using the null hypothesis that there are no significant differences between the two methods, the paired binary data for each question was evaluated using a McNemar test (*Table 2*). Next, the questionnaire answers provided by the radiographers were tabulated as ordinal values from a scale of 1 to 5. These were evaluated using the Sign test for ordinal values with

repeated measures (*Table 3*).

Lastly, the odds ratio of each baseline characteristic for preferring the slump sitting method compared to the standing forward bending method was determined (*Figure 1*) in an attempt to identify patients who preferred one posture over the other. Multivariate linear regression modelling was then performed using preference for the slump sitting method as a positive outcome.

Results

Of the 60 patients who participated in the study, 28 were male and 32 female. The mean age was 56.5 years (range, 44–79 years). There were no significant differences in baseline characteristics between the two groups, regardless which method of imaging was performed first. Details of patient characteristics and lumbar spine alignment parameters can be found in the previous study (1).

For this study, the results from the patient questionnaire is summarised in *Table 1*. Twenty-four preferred the conventional method while 36 preferred the new method ($P=0.044$). There were no significant differences between both methods in terms of subject's comfort, difficulty

Table 3 Summary of radiographer questionnaire responses

Question	Standing forward bending method (mean, SD)	Slump sitting method (mean, SD)	P
Radiographer's preference (%) [‡]	10 (17%)	50 (83%)	<0.001
Logistics required were readily available	3.73 (0.77)	3.11 (0.73)	0.031
A lot of effort was required to set up the posture	2.44 (0.92)	3.00 (0.95)	0.002
It was difficult to explain the posture to the patient	2.42 (0.87)	2.81 (0.86)	0.012
It was difficult to obtain a clear image in this posture	2.46 (0.94)	2.35 (0.74)	0.382
More exposure was required to obtain a good radiograph	2.35 (0.84)	2.25 (0.68)	0.358
It was difficult for the patient to achieve this posture	2.71 (1.05)	2.42 (0.78)	0.058
It was difficult for the patient to maintain this posture	2.90 (1.00)	2.31 (0.73)	<0.001
This posture was dangerous	2.81 (0.84)	2.44 (0.85)	0.015
This posture took up too much time	2.60 (0.77)	2.67 (0.86)	0.627

[‡], all values presented as mean except radiographer's preference shown as frequency (%). SD, standard deviation.

in achieving and maintaining postures during X-rays, time taken, and preference for future radiographs from the patients' perspective. The standing forward bending method however, was shown to more frequently cause pain than the slump sitting method ($P=0.025$). There was also a trend towards significance in patients finding the conventional method more dangerous than the new method ($P=0.054$). All comments obtained from the free text box of the questionnaire is presented in *Table 2*.

With regard to the radiographers responses (*Table 3*), 10 preferred the conventional method while 50 preferred the new method ($P<0.001$). There were no significant differences between both methods in terms of difficulty in obtaining clear images, amount of exposure required, and duration. The conventional method was logistically easier to perform. On average, the new slump sitting method required more effort and was more difficult to explain to patient. The new method however was felt by radiographers to be significantly less difficult to maintain and less dangerous.

There were no identifiable factors which predicted patient preference towards either posture (*Figure 1*). Patients with an ASA grade ≥ 2 had an odds ratio of 3.60 to prefer the new slump sitting method as a desired outcome—this however did not reach statistical significance. There was also no significant correlation between the radiographers' experience and the duration required to obtain X-rays or the number of X-rays taken (data not shown).

Discussion

The slump sitting posture flexes the lumbar spine more than the conventional standing forward bending posture (1,14). This stresses the lumbar spine into more flexion and aids in the diagnosis of sagittal lumbar instability, which as mentioned previously may affect surgical decision making; fusion may be indicated as a result in patients for whom isolated decompression have been previously preferred (10-12). In order for this new flexion method to be more widely implemented, the improved diagnostic yield should not come at the expense of patient safety and comfort, nor unnecessarily burden the duty radiographers (15-17).

Our study showed that the radiographers felt that the slump sitting posture is safer compared to the standing forward bending posture ($P=0.015$). Overall more patients felt that the standing forward bending posture was dangerous compared to the slump sitting posture, although this difference did not reach statistical significance ($P=0.054$). The slump sitting posture could theoretically reduce the risk of falls and related injuries (18). Patients sitting on the chair have a lower centre of gravity and don't have to support their own weight; this would be especially useful in patients with leg weakness or those unsteady on their feet. Furthermore, the enhanced safety of this posture allows patients to push themselves into maximum possible flexion without worry—the radiographs obtained are thus more likely to reflect a true stress view of the spine (19). Similarly, significantly fewer patients reported pain during

Parameter	Odds ratio	95% CI		P
Age > 60	2.44	0.63–9.40		0.219
Male gender	0.96	0.28–3.27		1.000
ASA grade ≥ 2	3.60	0.98–13.16		0.065
Severity of back pain ≥ 5	1.04	0.31–3.57		1.000
Duration of back pain ≥ 1 year	0.93	0.28–3.16		1.000
Presence of leg pain	0.74	0.20–2.72		0.752
Severity of leg pain ≥ 5	1.55	0.43–5.64		0.541
Duration of leg pain ≥ 1 year	0.34	0.09–1.27		0.169
Presence of paravertebral muscle tenderness	0.44	0.10–1.9		0.322
Schober's test positive	0.61	0.18–2.10		0.534
Hamstring tightness	0.41	0.11–1.51		0.197
Abnormal Beighton score	0.54	0.03–9.19		1.000

Figure 1 Odds ratio of each baseline characteristic for preferring the new slump sitting method as a desired outcome.

slump sitting compared to standing forward bending ($P=0.025$), which makes the patients less apprehensive when flexing. This appears to occur in spite of the increased stress created applied across the lumbar spine. While respecting selected spinal conditions may predispose to patients experiencing back pain during flexion or extension, this was not the main aim of the study and was hence not evaluated. Multivariate analysis showed there was a tendency for patients with ASA ≥ 2 to prefer the slump sitting posture, although again this did not reach statistical significance. This may be secondary to the greater comfort appreciated by patients with multiple co-morbidities when doing the slump sitting method (19,20).

From the radiographers point of view, the slump sitting method was perceived to be more easily achieved ($P=0.058$) and maintained ($P<0.001$). Patients themselves did not report any more difficulty holding their spines flexed in the slump sitting posture compared to the forward bending posture. With respect to the time taken to obtain the radiographs, there was no real or perceived difference between both methods from both the radiographers and patients' perspective. This is important as the imaging process is potentially time consuming and may interfere with the efficiency of the clinical workflow (21,22). From a technical viewpoint, both methods were also equivalent in terms of the perceived ease of obtaining images and the amount of radiation exposure required.

The slump sitting method is not without its limitations. Many radiographers felt that the slump sitting method was more logistically demanding ($P=0.031$), more difficult to explain to the patient ($P=0.012$), and required more effort to perform ($P=0.002$). These technical challenges may be related to the relative novelty of the positioning method in our institution, and could potentially be overcome via procedure standardization and practice (17,23,24). As the process of explaining and performing flexion X-rays in the slump sitting posture becomes more streamlined with repetition we believe the perception of these challenges will diminish (17). The slump sitting method inherently requires more logistics—we do not however feel that the additional chair required for the slump sitting method is prohibitive. Even though our study employed both visual aids (25) and verbal instructions (24,25) from radiographers when instructing patients to assume these X-ray postures, providing patients with an information leaflet prior to the imaging process may also ease some of the technical challenges faced by the radiographers (25).

This study was performed in a tertiary hospital with a dedicated spine division, supported by a large team of radiographers who help obtain the radiographs for all the patients. Our radiographers varied in terms of experience and training, but a multi-variable analysis performed did not reveal any association between the number of X-ray attempts, the overall imaging time and years of

experience of the radiographers (23). This reflects the fact that while imaging in the slump sitting posture may have been perceived to be challenging, it could be reliably and effectively performed regardless of radiographer's experience and training (26).

The slump sitting posture has already been shown to improve our ability to diagnose lumbar instability based on current guidelines. This study shows that it at the very least equivalent and in some aspects superior to the conventional standing forward bending method based on patient and radiographer feedback. It is hence our recommendation that it should be adopted as the standardised method for performing lumbar flexion X-rays, and subsequently be used to develop diagnostic criteria for spinal instability.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The National Domain-Specific Ethics Committee approval was obtained prior to study commencement, and written informed consent was taken for all subjects.

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Cite this article as: Hey HW, Choong DA, Lin AZ, Lau ET, Teo AQ, Liu G, Wong HK. Patient and radiographer assessment of slump sitting flexion compared to conventional standing forward bending flexion. *J Spine Surg* 2018;4(4):750-756. doi: 10.21037/jss.2018.09.07

Patient questionnaire

Overall I prefer position:



XRAY POSITION A: STANDING FORWARD BENDING		
COMFORT		
The X-ray position caused was comfortable	Y	N
The X-ray position caused pain	Y	N
DIFFICULTY		
The X-ray position was difficult to achieve	Y	N
The X-ray position was difficult to maintain	Y	N
SAFETY		
The X-ray position was dangerous	Y	N
DURATION		
I have no issues with the time taken	Y	N
PERSONAL		
I do not mind if I need to perform an X-ray in this position at my next follow up visit	Y	N
Any other comments about this position		

XRAY POSITION B: SLUMP SITTING		
COMFORT		
The X-ray position caused was comfortable	Y	N
The X-ray position caused pain	Y	N
DIFFICULTY		
The X-ray position was difficult to achieve	Y	N
The X-ray position was difficult to maintain	Y	N
SAFETY		
The X-ray position was dangerous	Y	N
DURATION		
I have no issues with the time taken	Y	N
PERSONAL		
I do not mind if I need to perform an X-ray in this position at my next follow up visit	Y	N
Any other comments about this position		

Figure S1 Patient questionnaire.

Radiographer questionnaire

Please help us to complete the following survey. Thank you for your time!

*Circle as appropriate

Start time:

End time:

Years of experience*: <1 year 1-3 years 3-5 years >5 years

Total number of X-rays taken for:

A: Standing forward bending	
B: Slump sitting	

Overall, I prefer position*:

A: Standing forward bending

B: Slump sitting

A: STANDING FORWARD BENDING	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
LOGISTICS The logistics required for the X-ray were readily available					
A lot of effort was required to set up the equipment for the X-ray					
INSTRUCTIONS It was difficult to explain to the patient what was required of them					
IMAGE ACQUISITION It was difficult to obtain clear images and distinct lines on the X-ray					
More X-ray films were required to achieve a suitable image of the spine					
EASE OF POSITIONING The patient displayed great difficulty trying to achieve the position					
The patient displayed great difficulty trying to maintain the position					
SAFETY The X-ray position was dangerous					
DURATION Too much time was spent positioning the patient					
Any other comments about the position					

B: SLUMP SITTING	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
LOGISTICS The logistics required for the X-ray were readily available					
A lot of effort was required to set up the equipment for the X-ray					
INSTRUCTIONS It was difficult to explain to the patient what was required of them					
IMAGE ACQUISITION It was difficult to obtain clear images and distinct lines on the X-ray					
More X-ray films were required to achieve a suitable image of the spine					
EASE OF POSITIONING The patient displayed great difficulty trying to achieve the position					
The patient displayed great difficulty trying to maintain the position					
SAFETY The X-ray position was dangerous					
DURATION Too much time was spent positioning the patient					
Any other comments about the position					

Figure S2 Radiographer questionnaire.