

EXTENDED REPORTS

Osteoarthritis of the hip: agreement between joint space width measurements on standing and supine conventional radiographs

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Abstract

Objective—To assess the effect of standing position on joint space width (JSW) measurements of the hips with and without osteoarthritis (OA) on pelvic radiographs.

Methods—Adult patients aged 18 or more had pelvic anteroposterior conventional radiographs standing and supine performed by a single radiologist in the same radiology unit according to standardised guidelines. JSW measurements in mm were made by a single reader blind to patients' identity and type of view, using a 0.1 mm graduated magnifying glass directly laid over the radiograph, at the narrowest point for OA hips or at the vertical joint space for non-OA hips. Agreement of JSW between both views was assessed using the Bland and Altman graphical analysis.

Results—JSW was greater on standing than supine radiographs, for example, 7.1% for OA hips. Mean (SD) differences and limits of agreement (mm) between both views were 0.08 (0.27) and -0.46 to 0.62 for the 70 non-OA hips, 0.02 (0.31) and -0.60 to 0.64 for the 46 OA hips. Corresponding 95% confidence intervals of mean differences were 0.02, -0.14 mm and -0.07, -0.11 mm.

Conclusions—Measurements of JSW of the hip on pelvic standing and supine radiographs are concordant. Changes less than or equal to 0.64 mm between the two views are similar or inferior to radiological progression of OA.

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standing position.¹⁰ Examination of the hip by pelvic radiograph while the patient is bearing weight has generally not been considered useful except for evaluation of the postoperative hip.¹¹ In recent guidelines for evaluating OA, it has been recommended that hip radiographs be performed with the patient standing,⁶ or supine,¹² or either.² In OA of the knee JSW is narrower on weightbearing than on non-weightbearing radiographs.^{7, 13, 14} Furthermore, JSW of the medial compartment of the osteoarthritic knee is accurately measured on weightbearing radiographs.¹⁵ Studies comparing JSW of the hip measured on weightbearing and non-weightbearing radiographs have given confusing results.¹⁶⁻¹⁹ Conrozier *et al*¹⁶ found that maximum joint space narrowing of the hip significantly decreased on weightbearing views compared with supine views only when considering OA hips with JSW less than or equal to 2.5 mm. Evison *et al*¹⁷ found that compared with non-weightbearing views, hip JSW decreased in two of 13 OA hips and increased or decreased in three of 25 non-OA hips on weightbearing views. For these authors, the latter view may be useful in selected groups of patients. Hansson *et al*¹⁸ have reported narrowing of JSW on weightbearing radiographs in 12 of 117 hips considered normal on non-weightbearing views. Of the 34 hips considered as narrowed on non-weightbearing radiographs only one became normal on weightbearing views in their study. Therefore, they did not recommend supine radiographs for assessing coxarthrosis. Other authors have shown radiographic narrowing of the joint space of 10% to 30% or more in hips weight free for 5 to 92 months as compared with weightbearing hips.¹⁹ In routine practice, hip OA is assessed on radiographs performed in supine or standing conditions. Consequently, the possibility of comparing epidemiological studies and clinical trials using radiographs performed with either type of patient positioning is limited if radiographs obtained with both patient positionings for measuring JSW of hip OA are not interchangeable.

The aim of this study was to assess the effect of the standing position on JSW measurements of the hip on pelvic radiographs.

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Assessment of articular loss has been shown to be important for evaluating the progression of osteoarthritis (OA) in epidemiological studies and clinical trials.¹ A measure of articular cartilage is considered the primary outcome variable of OA for structure modifying drugs. Several guidelines recommend that the measure of joint space width (JSW) determined on radiography should be used as a proxy for joint space narrowing.²⁻⁶ To study OA hips, radiographs are obtained with patients in supine⁷⁻⁹ or

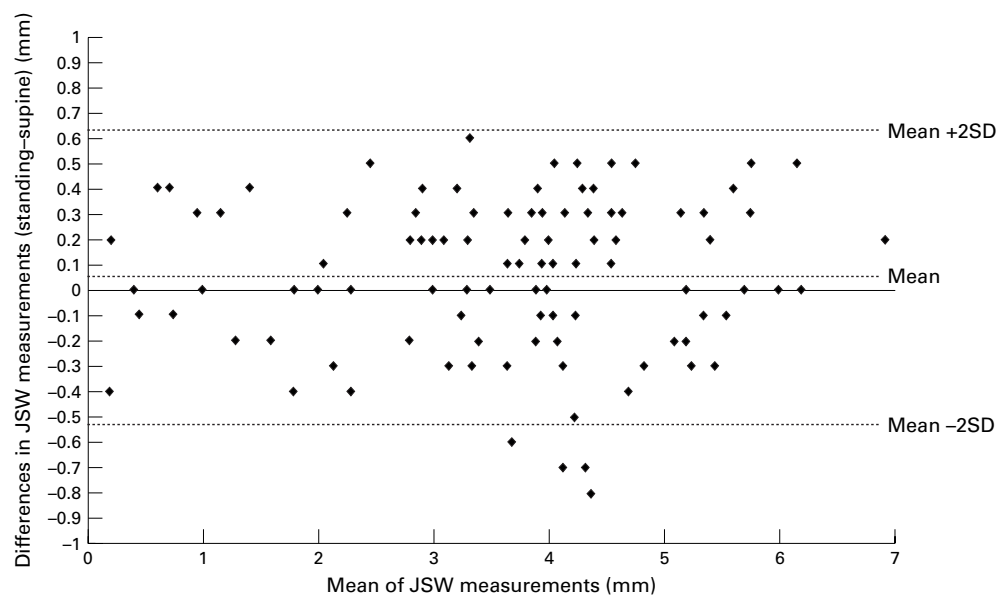


Figure 1 Differences in joint space width (JSW) (in mm) between standing and supine radiographs against the mean for all hips. Limits of agreement correspond to mean $\pm 2SD$.

Methods

PATIENTS

Consecutive patients of both sexes referred to a radiology unit for radiographic evaluation of the pelvis were eligible for the study. Other inclusion criteria were: age equal to or greater than 18 years, referral for chronic back pain, sciatica, bone neoplasia, myeloma or suspicion of hip OA. Patients were excluded if they had secondary hip OA defined by the presence or past history of hip fracture, inflammatory rheumatic disease, osteonecrosis, Paget's disease, or infectious disease.

RADIOGRAPHS

A single radiologist performed all radiographs in the same radiology unit according to a standardised procedure. For each patient, two conventional pelvic radiographs were made. The first film was performed in standing conditions. Anteroposterior radiographs were taken with a source to film distance of 110 cm. The patient's feet were internally rotated with the toes at $15 \pm 5^\circ$ with the help of fluoroscopy to ascertain that the x ray beam was centred on the superior aspect of the pubic symphysis. The x ray beam was horizontal, perpendicular to the table. Patients were standing on both legs and were asked to distribute their weight equally on both feet.

After patients gave informed consent, the second film was performed in supine conditions using the same radiological procedure (incidence, source to film distance, rotation of patient's feet) as for standing films except that the x ray beam was vertical.

The radiologist (BR) classified radiographs as with hip OA (definite osteophytes and joint space narrowing)²⁰ or not (absence of osteophytes and joint space narrowing).

RADIOGRAPHIC ASSESSMENT

All the radiographs were collected and the patients' identity and the type of view were masked with an adhesive tape by one investigator (REN). The patients' identification was replaced by a random code number. Radiographs were assessed blind to the view performed by one reader (GRA). Before masking, the two radiographs of a single patient were placed side by side on a light box and the landmarks for measurements were drawn by the reader. The landmarks consisted of two points, one on the distal margin of the condylar cortex for the femoral surface and the other on the margin of the bright radiodense band of the subchondral cortex in the floor of the articular fossa for the acetabulum. This interbone distance was measured in millimetres using a 0.1 mm graduated magnifying glass directly laid over the radiograph at the narrowest point for OA hips and at the vertical joint space for non-OA hips. In addition, for OA hips joint space narrowing was graded 0–3 using a radiographic atlas²¹ and overall severity of OA was graded using the Kellgren and Lawrence criteria.²²

In radiographs classified by BR as without hip OA, both hips were examined except for two radiographs with unilateral prosthetic hip related to femoral neck fracture. In radiographs classified by BR as with hip OA, both hips were

Table 1 Means (standard deviations) and (range) (mm) of joint space width in 46 hips with osteoarthritis and 70 hips without osteoarthritis on pelvic standing and supine radiographs during two reading sessions

	Standing without osteoarthritis (n=70)	Supine without osteoarthritis (n=70)	Standing with osteoarthritis (n=46)	Supine with osteoarthritis (n=46)
First reading session	4.51 (0.90) (2.7–7.0)	4.43 (0.90) (2.7–7.0)	2.51 (1.33) (0–5.0)	2.50 (1.36) (0.1–4.7)
Second reading session	4.48 (0.92) (2.7–7.0)	4.40 (0.87) (2.5–6.5)	2.50 (1.35) (0.1–4.7)	2.50 (1.34) (0.2–4.7)

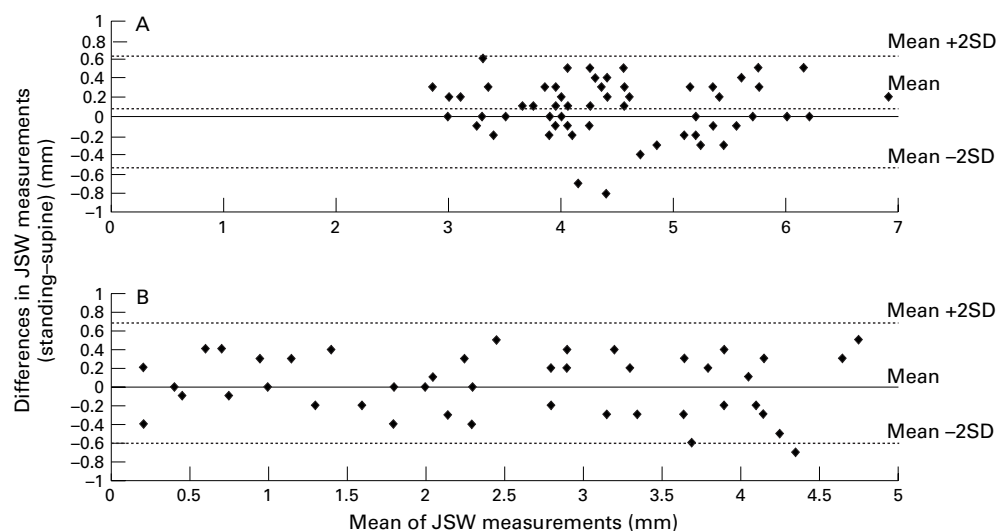


Figure 2 (A) Hips without osteoarthritis. Differences in joint space width (JSW) (in mm) between standing and supine radiographs against the mean for hips without osteoarthritis. Limits of agreement correspond to mean $\pm 2SD$. (B) Hips with osteoarthritis. Differences in joint space width (JSW) (in mm) between standing and supine radiographs against the mean for hips with osteoarthritis. Limits of agreement correspond to mean $\pm 2SD$.

examined except for 10 radiographs with unilateral prosthetic hip (two radiographs) or unilateral normal hip (eight radiographs). The reader (GRA) separately measured all JSW of OA and non-OA hips in one reading session.

A week later, the same reader, unaware of the results of the first reading session, measured all JSW of OA and non-OA hips. In this second reading session, the radiographs had their random code number and were evaluated in a different order.

STATISTICAL ANALYSIS

Means and standard deviations (SD) of JSW measurements in both views during each reading session, and their differences were calculated. JSW of hips measured on standing radiographs were also presented as a relative percentage of JSW measured on supine radiographs using the difference between JSW on supine and standing radiographs as the numerator and JSW on supine radiographs as the denominator.

The first step of analysis consisted in evaluating the agreement between JSW measurements on standing and supine radiographs. For this purpose, the magnitude of changes, including those related to the patient's position was assessed in all, non-OA, and OA hips. For all these groups, the graphical analysis described by Bland and Altman^{23, 24} was applied. This method focuses on differences between pairs of measurements of the same quantity against their corresponding mean. Graphs were plotted for each of these groups. Limits of agreement were estimated as $d_{\text{mean}} \pm 2SD$, where d_{mean} is the mean difference and SD, the standard deviation of the differences.

The second step consisted in evaluating the magnitude of changes that might result from measurement error. This magnitude was also estimated by using Bland and Altman graphical analysis on measurements repeated one week apart of OA and non-OA hips either in standing or supine radiographs.

Results

Sixty four patients (42 women and 22 men) were included. They had a mean age of 66 (range 38–92) years. A total of 116 hips, regardless of whether they were OA, were available for analysis. Means (SD) of JSW were 3.72 (1.45) mm and 3.66 (1.45) mm on standing and supine radiographs, respectively. The differences in measurements between the two views varied from -0.6 mm to 0.7 mm. Figure 1, plotting the difference between pairs of measurements against the corresponding mean of each hip, shows that there was no relation between the difference and the mean. On average, JSW was 4.1% (SD, 25.6%) greater on standing than on supine radiographs.

JSW was measured in 70 non-OA hips. Table 1 gives the means (SD) of JSW measurements. The differences in measurements between the two views varied from -0.6 mm to 0.7 mm and their variation did not depend on their mean (fig 2A). On average, JSW was 2.2% (SD, 6.3%) greater on standing than on supine radiographs.

Forty six OA hips were available for measurement of JSW. They were graded 2 ($n=29$), 3 ($n=11$) or 4 ($n=6$) in the Kellgren and Lawrence grading system and graded 1 ($n=30$), 2 ($n=13$) or 3 ($n=3$) in the joint space narrowing grading scale. Means (SD) of JSW measurements were identical between standing and supine radiographs (table 1). The differences in JSW between the two views varied from -0.6 mm to 0.7 mm. No relation existed between the difference and the mean (fig 2B). JSW was 7.1% (SD, 40%) on average greater on standing than

Table 2 Comparison of joint space width measurements on standing and supine radiographs of 46 hips with osteoarthritis

Standing	Supine		Total
	> 3.0 mm	\leq 3.0 mm	
> 3.0 mm	16	2	18
\leq 3.0 mm	1	27	28
Total	17	29	46

Table 3 Variability between views or between reading sessions of joint space width (mm) of hips with osteoarthritis and hips without osteoarthritis (OA) on radiographs performed in the same patients

	Number	Mean differences	Standard deviations	95% confidence intervals	Limits of agreement
Between views					
all	116	0.05	0.29	0.0, 0.10	-0.53 to 0.63
without OA	70	0.08	0.27	0.02, 0.14	-0.46 to 0.62
with OA	46	0.02	0.31	-0.07, 0.11	-0.60 to 0.64
Between reading sessions					
standing without OA	70	0.03	0.13	0.0, 0.06	-0.20 to 0.26
supine without OA	70	0.03	0.13	0.0, 0.06	-0.20 to 0.26
standing with OA	46	0.02	0.11	-0.01, 0.05	-0.20 to 0.24
supine with OA	46	-0.002	0.13	-0.04, 0.04	-0.26 to 0.26

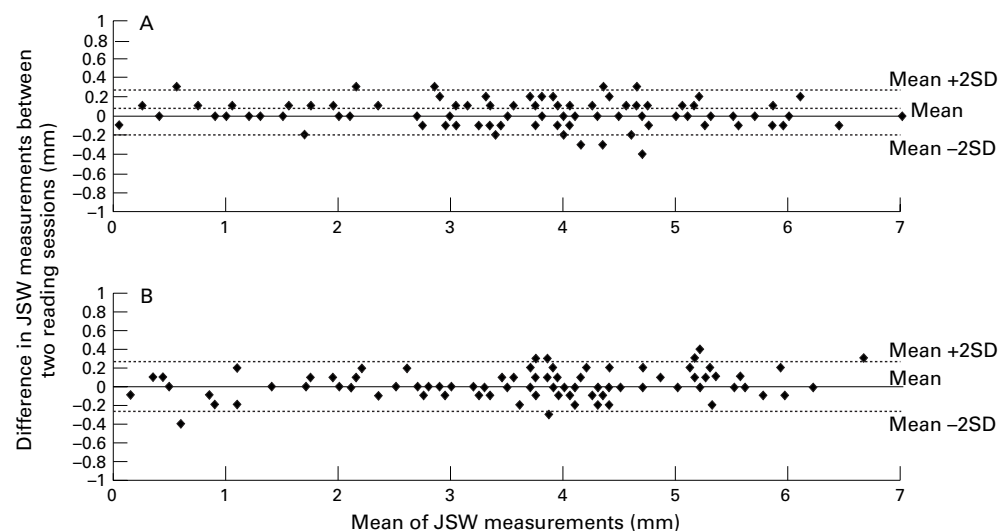


Figure 3 (A) Standing radiographs. Differences in joint space width (JSW) (in mm) for standing radiographs between two reading sessions against the mean for all hips. Limits of agreement correspond to mean \pm 2SD. (B) Supine radiographs. Differences in joint space width (JSW) (in mm) for supine radiographs between two reading sessions against the mean for all hips. Limits of agreement correspond to mean \pm 2SD.

supine radiographs. When considering the 23 hips with JSW less than or equal to 2.5 mm on the one hand and the 23 hips with JSW greater than 2.5 mm on the other hand, mean differences (SD) of JSW between the two views were 0.01 (0.26) mm and 0.02 (0.37) mm, respectively. When considering the limit for definite narrowing of joint space as less than or equal to 3 mm, one of the 17 hips with a normal joint space on the supine radiograph was reclassified on standing. Two of the 29 abnormal hips on the supine radiograph were reclassified normal on standing (table 2).

The largest magnitude of changes related to the measurement error was observed in non-OA hips (mean difference=0.03 mm) and the smallest in OA hips in supine radiographs (mean difference=-0.002 mm) (table 3). Comparison of JSW between two reading sessions showed wider limits of agreement for OA hips radiographed in supine conditions (-0.26 to 0.26 mm). No relation appeared between the measurement error and the estimated true value (fig 3).

Table 3 summarises also mean differences (SD), 95% confidence intervals, and limits of agreement. All confidence intervals overlapped zero.

Discussion

Measurements of JSW of hip with or without OA on conventional pelvic anteroposterior

radiographs performed in standing and supine conditions are concordant. Mean differences (SD) and limits of agreement between the two views were 0.08 (0.27) mm, -0.46 mm to 0.62 mm, and 0.02 (0.31) mm, -0.60 mm to 0.64 mm in non-OA and OA hips, respectively. These limits of agreement suggest that changes of less than 0.64 mm between JSW measurements on standing and supine radiographs are within the normal variability of measurements. Indeed, such variability is clinically relevant as it is similar to or less than a change in JSW proposed by others to define radiological progression of OA related to the course of the disease.^{10 25}

Mean differences in JSW were less than 0.1 mm in our study whereas those found statistically significant in other studies were 0.13 mm¹⁶ and 0.3 mm.¹⁸ The reader measured JSW blind to the patient's identity and to the type of view in our study. It is not stated whether others did the same when comparing the two views.¹⁶⁻¹⁹ When comparing methods of measurement, knowledge of the result by one method (lack of blind) may affect the result of the second measurement, resulting in a bias effect. The Bland and Altman graphical method permits this effect to be assessed along with the random effect.

As possible bias between repeated measurements can limit the amount of agreement,^{23 24 26} study of reproducibility of measurements on each view was relevant and allowed to

distinguish changes related to measurement error from changes related to patient's position.

We compared JSW measurements obtained on weightbearing and non-weightbearing radiographs using Bland and Altman graphical plots. This method is appropriate when comparing methods of clinical measurement.^{26 27} What we intended to assess was how well JSW measurements agree for individual people. Statistical methods like the test of significance for means are irrelevant to the question of agreement.^{28 29}

Our results differ from those found for the knee joint. Differences in biomechanics of the hip and the knee may explain such discrepancies. Deformations of the hip articular cartilage when just standing have not really been studied. However, the pressure exerted through the hip when standing with body weight equally distributed on both feet may be less than when walking.^{30 31} Furthermore, the pressure exerted on the hip may exceed half the body weight when subjects are lying, either prone or supine.³²

Our results differ from those found elsewhere, especially by Hansson *et al.*¹⁸ In our study, narrowing of the hip joint on standing radiographs was observed in one (2.9%) of the hips considered normal on supine radiographs. But narrowing of hip joint on supine radiographs was observed in two (11%) of the hips considered normal on standing radiographs. In contrast, Hansson *et al* found narrowing of the hip joint on standing radiographs in almost 10% of the hips considered normal on supine radiographs, whereas they found narrowing of the hip joint on supine radiographs in only 0.9% of the hips considered normal in standing radiographs. Several factors may explain such differences in results. Unlike us, Hansson *et al* did not use a blinding procedure during measurement of JSW. Moreover, in our study radiographs were performed with patients' feet internally rotated in standing and supine positions. Hansson *et al* performed radiographs with patients' feet internally rotated during supine radiographs and in neutral position during standing radiographs. It has been reported that rotation of the foot during the radiograph may influence JSW measurement.³³ Finally, our patients had pelvic radiographs while those included by Hansson *et al* had hip radiographs. The direction of the x ray beam may also contribute to differences in JSW measurements.^{6 33}

A limitation of this study was that we did not assess whether longitudinal radiographs performed in the same patient in standing and supine conditions are also concordant.

We have shown that standing and supine radiographs of the hip in the same patient allow identical measurements of JSW. Evaluating whether serial standing and supine radiographs of the hip allow identical JSW remains to be performed.

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