Published in final edited form as:
Osteoarthritis Cartilage. 2014 October ; 22(10): 1481–1487. doi:10.1016/j.joca.2014.05.017.

LOCATION-SPECIFIC HIP JOINT SPACE WIDTH FOR PROGRESSION OF HIP OSTEOARTHRITIS - DATA FROM THE OSTEOARTHRITIS INITIATIVE

C. Ratzlaff[1,2], **C. Van Wyngaarden**[3], and **J. Duryea**[1,2]

[1]Brigham and Women's Hosp., Boston, MA, Alberta, Canada

[2]Harvard Med. Sch., Boston, MA, Alberta, Canada

[3]Northern Lights Regional Health Care Centre, Alberta, Canada

Abstract

Objective—To establish the performance of a location-specific computer-assisted quantitative measure of hip JSW, by measuring responsiveness at fixed locations in those with hip OA and pain and those without. Secondary purposes included investigating the most responsive location, comparison to mJSW and evaluating reading time.

Methods—Design: nested case-control

Data: drawn from the Osteoarthritis Initiative (OAI), a longitudinal cohort study of knee OA. All OAI participants had standardized standing AP pelvis radiographs at baseline and 48 months.

Case definition (1): subjects with a total hip replacement (THR) after the 48 month visit with adequate baseline and 48 month radiographs (n=27) were selected and matched (1:1) on sex and age to subjects without a THR and no hip pain.

Case definition (2): subjects with a THR at any point after baseline (n=79) were selected and the *contralateral* (CL) hip was designated the case hip, and subjects were matched (1:1) as above.

Pain: the CL hip group were examined for the presence/absence of pain

Address for correspondence: Charles Ratzlaff, Radiology Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 2115 Thorne Building, Room 334D Attn: Dr Jeff Duryea cratzlaff@bwh.harvard.edu.

Author contributions:
Study conception and design - *Ratzlaff, Duryea, VanWynaarden*
Acquisition of data – *Duryea, Ratzlaff*
Analysis and interpretation of data – *Ratzlaff, Duryea, VanWynaarden*
Drafting the article or revising it critically for important intellectual content - *Ratzlaff, Duryea, VanWynaarden*
Final approval of the version of the article to be published - *Ratzlaff, Duryea, VanWynaarden*
C Ratzlaff (cratzlaff@bwh.harvard.edu) takes responsibility for the integrity of the work as a whole.

Conflict of Interest: none

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Measurements of superior hip JSW were made at three fixed locations relative to a landmark-based line, facilitated by software that delineated the femoral head and found the acetabular margin at the three points.

The standardized response mean (SRM) was used to examine sensitivity to change from baseline to 48 months. Paired t-tests were used to compare cases and controls.

Results—Significant differences were observed between cases and controls and those with and without pain. The location-specific measure outperformed mJSW in all analyses, with SRM ranging from 0.53 (contralateral hip) to 1.06 (THR hip). The superior-medial location was the most responsive.

Conclusion—A new computer-assisted location-specific method of hip JSW is feasible and may provide a superior method to mJSW for radiographic OA progression. The superior-medial location was the most responsive.

Keywords

Hip osteoarthritis; Radiography; Joint space width; Computer measurement

INTRODUCTION

Expert consensus groups [1, 2] and the United States Food and Drug Administration (FDA) [3] have stated that radiographic joint space width (JSW) in hip osteoarthritis (OA) is adequate (and the only FDA-recommended) method for evaluation of structural change in hip OA intervention trials. Hip JSW has received limited research attention in comparison with the knee, even though it is likely a more direct measure of cartilage thickness. At the knee a substantial proportion of radiographic JSW loss is due to factors other than cartilage thickness, including meniscal damage, meniscal extrusion and variability in patient positioning [2, 4, 5]. By contrast, the hip does not have menisci and patient positioning in standardized anteroposterior pelvic radiography is less problematic.

Despite its importance in drug and therapy development, the relevance of JSW as an outcome remains somewhat doubtful [6]. Responsiveness is a key issue since progression of disease is frequently slow and variable. The best and most commonly metric is minimum JSW (mJSW), measured manually or with computer assistance. The most responsive and suitable mJSW is with a computer assisted method [6, 7]. Either way the location of mJSW is subjectively selected, can be time-consuming, susceptible to structural damage that can confound joint margin detection or cause inconsistencies including measurement at different locations (within and between subjects) on serial radiographs, leading to measurement error that can approach annual change [8]. A reliable, responsive and efficient computer-assisted measure of hip JSW could be a significant advance for large cohort studies and trials.

To address these issues at the knee, we previously developed and validated a semi-automated software measure of location-specific JSW relative to a coordinate system, which was found to be more responsive and robust than mJSW and has been used in numerous studies [9] We now extend a similar computer-assisted method of fixed location measurement of JSW to the hip.

The primary purpose of this study was to establish the performance of a novel location-specific computer-assisted quantitative software measure of hip JSW, by measuring responsiveness at fixed locations in those with hip OA and pain and those without. Secondary purposes included investigating the most disease-responsive location, comparing the location-specific measurement to mJSW and evaluating the reading time required.

Methods

Subjects—Data used in the preparation of this article were obtained from the Osteoarthritis Initiative (OAI) database, which is available for public access at http://www.oai.ucsf.edu/. The OAI is a multi-center longitudinal cohort study of biomarkers and risk factors for the development and progression of knee OA in 4,796 subjects. General exclusion criteria (for all OAI participants) included rheumatoid or inflammatory arthritis, bilateral end-stage knee OA and MRI contraindications. A full description of study protocol, design, data overview and the datasets are available for public access at http://www.oai.ucsf.edu/. The study was HIPAA compliant and all subjects provided informed consent. The study protocol, amendments and informed consent documentation were reviewed and approved by the local institutional review boards.

Image Acquisition—All OAI participants had standing anterior-posterior (AP) radiographs at baseline and 48 month visits using a standardized protocol. Radiographs were performed in the weight-bearing position using a positioning frame ("SynaFlexor", TM) with the subject facing the X-ray tube, the feet internally rotated 5 degrees with assistance of a v-shaped foot angulation support and the body weight distributed equally between the two legs. The X-ray beam was horizontal, perpendicular to the film and centered two inches above the pubic symphysis at the level of the greater trochanter, collimated to the size of the film with the iliac bones included entirely. The radiography protocol called for an extremity detail film cassette (Agfa Ortho Fine), with a 40 inch film to focus distance. The radiography technique called for a 70-80 kVp range with a variable mAs.

Study sample and design—For the current study we used a nested case-control design. We used two case definitions. Total Hip Replacement (THR). Subjects who had a total hip replacement (THR) sometime *after the 48 month visit* (at 60 and 72 months) and therefore had AP pelvic films at 0 and 48 months, were selected. After eliminating those with unavailable or poor quality films, 27 cases were included and matched (1:1) on sex and age (2 years) to subjects without a THR and no hip pain during the study period.

Contralateral hip of a THR: Since there is evidence that JSW narrowing occurs in the contralateral hip after THR [10] and since hip OA severe enough to require THR likely alters the biomechanics of contralateral joint loading, we also defined a second larger set of cases. This included all subjects who had a THR at any point after baseline and had good quality AP pelvis films at 0 and 48 months (n=79) for the contralateral hip. Subjects were matched (1:1) as above.

Pain: The primary pain definition was pain in the groin and/or the front of the leg near the hip. Since lateral pain can sometimes be from articular hip pain but is frequently the result of

non-hip joint sources such as the low back and local soft tissue [11, 12], we also collected data on lateral hip pain to use as part of the pain definition in a sensitivity analysis of the pain outcome.

To collect data on pain, subjects were asked at each OAI visit the following 2-stage question regarding hip pain:

1. "During the past 12 months, have you had any pain, aching, or stiffness in or around your right hip? This includes pain in the groin and in the front and sides of the upper thigh."

If the reply was yes, they were asked a follow-up location that included the following as multiple-choice answers:

2. "Where is this pain, aching, or stiffness located? Please look at this drawing and point to all the places you have hip pain." (Subjects were shown a diagram by the examiner with the areas of the hip indicated to guide selection).
    1. Groin/Inside leg near hip
    2. Outside of leg near hip
    3. Front of leg near hip

Measurement of JSW at fixed locations: The procedure was modeled after a previously developed and validated method at the knee which was found to be more responsive and robust than mJSW and had good reliability[9]. At the hip, an analogous methodology was employed. Measurements of superior hip JSW were made at 3 fixed locations relative to a line extending from the femoral head centre to the outer edge of the acetabular roof (Figure 1, red line). While a Cartesian coordinate system was used to establish locations in the knee joint, polar coordinates were used for the hip.

To establish the reference line a reader placed a mark on a digital radiograph at the lateral edge of the acetabular roof, and the computer delineated the femoral head and found its centre. A line was then placed by the computer between these two points, as well as at 10, 30 and 50 degrees medial to the reference line.

Position 1 (Figure 1) was in the supero-lateral hip and was 10° degrees to the right of the line (both left and right hips were oriented the same way to facilitate software operation). Position 2 was supero-central and was 30° from the line. Position 3 was supero-medial and was 50° from the line. The process was semi-automated, facilitated by software that delineated the femoral head and found the acetabular margin along each of the lines. When required, a reader used a graphical user interface software tool to correct margins.

Measurement of minimum joint space width (mJSW): mJSW was measured as the minimum distance between the delineated femoral and acetabular margins in the superior compartment. The software delineated the femoral head and reader judgment was employed to select the point on acetabulum which represented mJSW.

For all JSW measures (location-specific and mJSW), image files were prepared by a different researcher than the reader and randomly assigned filenames ensured that the reader had no knowledge of the correct time sequence. Baseline and follow-up images were displayed separately such that the reader was blind to chronological sequence.

Reliability—Reliability was assessed on a random sample of 20 subjects. For intra-rater reliability, readings were separated in time by 8 weeks to avoid recall bias. Inter-reader reliability was assessed on the same 20 cases by an experienced radiologist (CV).

Statistical analysis—Hip joint space width (mm) was calculated by the computer for each hip at baseline and 48 month follow-up and the 48 month mean change (and standard deviation) for all 3 locations and mJSW were calculated. As a metric to quantify performance we used the SRM, or the ratio of the mean loss to the standard deviation of the loss. We report the SRM values along with the means (SD) at baseline and 48 months, the mean (SD) 48 month change for each case and control group, and for those with and without hip pain in the contralateral hip group. We also compared the location-specific to mJSW for both case groups. Paired t-tests were used to test statistical significance between cases and controls.

Since it is often not clear whether lateral hip pain is of hip-articular origin or from outside the hip joint[11, 12] particularly in early to moderate disease, we conducted a sensitivity analysis where lateral hip pain was included in the definition. We hypothesized (based on lateral hip pain often being of low back or local soft tissue origins), that it would substantially increase the number of contralateral hips with hip pain and attenuate the relationship between pain and change in JSW.

For both intra-reader and inter-reader reliability, the Shrout-Fleiss intra-class correlation coefficients (ICC) were calculated as measures of agreement.

Results

The overall sample was 42% male, 88% Caucasian had a mean age of 64.2 and BMI of 27.9

Baseline JSW for cases and controls were similar and were not significantly different, with the exception of mJSW for THR cases (cases 2.89mm, control - 3.48mm p=0.02) (Table 1). At the 4-year follow-up, significant differences were observed between cases and controls in both groups for mJSW and location-specific JSW (Table 1 and 2; Figure 2). For the THR group, the mean loss in JSW at superior lateral position (1) was -1.51mm, while at the superior medial position (3) it was -1.29mm. The SRM for location 1 and 3 was -1.06 and -1.04 respectively. For the contralateral hip group, location 3 was the most responsive with a 4-year change of -0.40mm and SRM of -0.53. In both groups controls showed little change in JSW over 4 years.

Among the contralateral hips with pain the mean 48 month change and SRM were greatest for the superior medial location (3) (48 month change -0.90mm, SRM 0.74). L0.54 in those without pain (48 month change 0.26mm).

In all analyses, location 3 (superior-medial hip) outperformed mJSW as measured by both raw JSW change and SRM. In the sensitivity analysis of the 79 contralateral hips where the pain definition included lateral hip pain we found that 48% (37 of 79) of contralateral hip subjects had lateral hip pain, and that of these, 29% (23 of 79) had only lateral hip pain. This compares with 22% (17 of 79) that had only groin and/or anterior hip pain. Using the alternative pain definition there were no significant differences between painful hips and non-painful hips in either mJSW or location-specific JSW, or in the SRMs. In the THR group, 23 of 27 subjects (85%) had lateral hip pain as part of the presentation.

The ICC's for intra-reader reliability were 0.85, 0.80 and 0.88 for location 1 (sup-lat), 2 (sup-central) and 3 (sup-med), respectively. For inter-rater reliability, the ICC's were 0.88, 0.93 and 0.84.

Discussion

Similar to findings at the knee [9], location-specific computer measures of hip JSW are feasible and provide a superior method to mJSW for radiographic OA progression. Evidence from this study suggests that the superior-medial hip may be the best location for measuring longitudinal JSW change in the hip joint, outperforming mJSW for responsiveness in all analyses. The superior-lateral location in the most diseased hips performed similarly to the superior-medial location.

While selecting and measuring the location of perceived mJSW on each radiograph would intuitively yield the biggest serial change in JSW, the better location-specific result may overcome difficulties associated with serial measurement of a degenerating joint. The enhanced responsiveness may be explained by the need to have unambiguous joint margins present on the radiographic image to facilitate consistent delineation of the joint space [9]. Second the use of landmark- based consistent locations that cover the joint space systematically may be less susceptible to structural damage that can confound joint margin detection or cause inconsistencies from baseline to follow-up. Third, once disease becomes more severe and approaches bone on bone status - often evident at the medial and lateral joint margins - the amount of further narrowing is limited, whereas JSN can be better observed at locations away from the bone on bone region.

The location-specific method clearly distinguished 4-year change in JSW between controls and THR cases. It also distinguished 4-year changes between controls and the contralateral hips of a THR hip. As expected the change was smaller than in the THR group, but remained significant. There was no appreciable decline in the JSW of controls, consistent with other studies [13, 14].

Amongst the contralateral hips the method also detected significant differences between those with and without hip (anterior hip or groin) pain, both at the superior-lateral (1) and superior-medial (3) locations. At the superior-medial joint the difference was stronger and more clearly clinically meaningful (mean change 0.90mm, SRM -0.74).

The method was also reliable and efficient, requiring an average of 1 minute per hip reading time. Other studies have not reported on the time required to measure hip JSW. A rapid

method has the potential to more cost-effectively study large cohorts (e.g., 1000s) in a shorter period.

The superior medial hip joint space (3) was highly responsive in both case groups, as well as in those reporting hip pain over the 4 years. The supero-lateral joint space (1) was highly responsive in the THR group as well (SRM 1.06 vs. 1.04). This difference in the most involved case group (those going onto THR) may reflect a more advanced (i.e., progression) state of disease, though are sample size was not large. Location 2 (superior-middle) was the least responsive in all analyses and was only statistically significant in the THR group.

To our knowledge, no other studies have measured location-specific change in hip JSW using a robust coordinate system. However, several studies have reported on JSW from locations within the superior hip joint space. Lequesne et al reported on JSW in 223 healthy subjects. Several other groups report measuring hip JSW at multiple locations at the hip, although none did so in reference to an anatomical landmarks and analyzed each location separately. Measuring the hip JSW at the same fixed location on baseline and follow-up scans may improve consistency in longitudinal studies, and by selecting the most responsive location, decrease power and sample size required to observe clinically meaningful change. The locations of our measurement may vary across individuals but remain consistent for a given hip.

Other studies have reported variation in mean annual progression from 0.01mm to 0.37mm [15-19] in studies of between 1 and 3 years. In comparison, our total mean change in JSW over was 1.51mm for THR cases at 4 years, at the superior lateral location for an annual change of approximately 0.38mm per year. The high annual change may in part be explained by the endpoint of THR, a more severe from of disease though several other studies have used a similar endpoint. In the contralateral hips of those with THR, 4-year change was 0.10 mm/year, similar to the findings of Goker et al [10], who measured JSW change in the contralateral *after* a THR, to Chevalier et al [15] who measured the contralateral hip of symptomatic OA hip patients (ACR criteria plus KL 2 to 3) and to other studies measuring JSW change in established OA hips (i.e., not contralateral).

The SRM is a better measure for comparing responsiveness between methods and provides information about the importance of an identified difference when using different types of instruments with different scoring and ranges of variation (i.e., how well one can distinguish the “signal” from the “noise”). In general an SRM > 0.80 is considered a large effect size [20], and the sample size required for a study drops by a factor of 4 for each doubling of the SRM . The SRM for THR cases in this study at the superior location was 1.06. Other studies have reported SRMs ranging from 0.37 to 1.16 over follow-up periods of 1-8 years [15-19, 21-24]. In a recent systematic review by Chu et al [6] on the responsiveness of radiographic quantitative measurement in hip OA in high quality studies, responsiveness was found to be moderate (SRM 0.66; 95% confidential interval (95%CI): 0.41, 0.91), though was better in studies that used computer-assisted versus manual measurement of JSW.

Manual measures have been used traditionally but there is evidence that computer-assisted measures may have better sensitivity. In a 2001 study Conrozier er al. [7] investigated several radiographic measures for hip OA progression and found that minimum interbone distance was the most responsive measure, and that computer assisted measure was more responsive than using a manual eye-piece (SRM: 0.85 vs 0.79). Our computer-assisted method of location-specific JSW performed better than both these findings, however direct comparison to other studies is difficult since factors such as the disease status and length of follow-up time affect the responsiveness.

Our definition of hip pain deserves comment. Lateral hip pain was excluded from the primary definition, based on evidence and our clinical experience that, especially earlier in disease, it is often not of articular hip origins. In the sensitivity analysis it was noted that inclusion of the lateral hip pain changed the result for both mJSW and location- specific JSW, supporting the evidence that lateral hip pain, especially earlier in disease, may not be articular origin. Of note, in the THR group – where the superior-lateral joint space was as responsive as the superior medial, the vast majority of cases had lateral hip pain (23 of 27, or 85%) as part of the presentation, while in the contralateral group 23 of 79 (29%) had only lateral hip pain and 37 of 79 (47%) had lateral hip pain in addition to groin or anterior pain. It may be that in some types of more severe hip disease the lateral hip joint becomes increasingly more narrowed and the hip joint contributes more consistently to lateral hip pain.

A strength of the location-specific method was that we did not have to delineate the acetabular margin and the method did not require selection of the location of the minimum inter-bone distance – a problem with mJSW measures. Conrozier et al. [16] reported on a novel measure of computer measurement of hip mJSW, finding it provided good sensitivity to change, but that it was necessary for the observer to intervene frequently to select the region of mJSW and adjust detection of the bone edge. In the current study, we have overcome problems with selection of mJSW region by selecting specific fixed locations. This also overcomes the problem of where to mark the minimum when there is no local minimum. Another advantage to location-specific measures coupled with a computer-assisted method may be an improvement in reproducibility. It has been observed by Vignon et al [8] and others that with repeated measures it is common to have discrepancy in the range of 0.2mm (or greater), greater than the average annual JSW loss in hip OA. Vignon postulated that the primary reason for this is that the location of JSW measurement were not at identical locations on repeated measures, i.e., the point of minimum JSW is defined differently on serial radiograph[8]. Another strength was the efficiency (<1 min/hip). The method used an automated computer detection algorithm to demarcate the femoral head and it worked well. While there was a need for periodic reader intervention to modify computer selections, it was most often on the acetabular side and corrections were rapid, since only 3 spots along the acetabular margin were required, with the computer usually locating them accurately. The method is flexible and JSW at locations other that 10, 30, and, 50 degrees could easily by made.

A significant limitation of the study was the relatively small sample size of the THR group (27 cases, 27 controls), and further studies in larger cohorts should be undertaken. We also

limited measurement to the superior hip joint space, potentially missing important changes in the inferior space. However, the superior space is the most widely used clinically and in the research setting, and is thought to be the more responsive. Thirdly, the 3 measured locations are in relation to a reference line that is located in part by the computer (centre of femoral head) and observer (lateral margin of acetabular roof) - which could vary on serial markings. However, we found that these landmarks were highly reproducible on serial radiographs of the same hip. Lastly, while we matched cases to controls on age and gender, residual confounding may persist, particularly if cases had more advanced disease at baseline than controls. This was the case for the mJSW between cases and controls for the THR group (Table 1). However there were no significant differences for the contralateral hip group, nor for any of the baseline location-specific JSW measures in either case-control group. (There were also no baseline difference between the pain and no pain group, Table 3). Of note, the primary purpose of the study was to establish the responsiveness of the novel measure of hip JSW in those with hip OA and pain and those without and not to predict outcome based on baseline JSW or to compare groups using a measure of association (e.g., OR). In that case, the selection of controls could have lead to misclassification (non-differential or differential) and biased a measure of association (such as an OR).

Conclusion

A new computer-assisted location-specific method of hip JSW is feasible and may provide a superior method to mJSW for radiographic OA progression. Evidence from this study suggests that the superior-medial hip may be the best location for measuring longitudinal JSW change in the hip joint, outperforming mJSW for responsiveness in all analyses. The superior-lateral location in the most diseased hips performed similarly to the superior-medial location.

It is also rapid, taking approximately one minute per hip. Location-specific measures of JSW are an efficient and possibly improved method to assess progression of hip OA.

Acknowledgments

We acknowledge the work of Quinley Maio and the funding support of the NIH/NIAMS (R01AR056664) and the Canadian Institutes of Health Research.

The OAI is a public-private partnership comprised of five contracts (N01-AR-2-2258; N01-AR-2-2259; N01-AR-2-2260; N01-AR-2-2261; N01-AR-2-2262) funded by the National Institutes of Health, a branch of the Department of Health and Human Services, and conducted by the OAI Study Investigators. Private funding partners include Merck Research Laboratories; Novartis Pharmaceuticals Corporation, GlaxoSmithKline; and Pfizer, Inc. Private sector funding for the OAI is managed by the Foundation for the National Institutes of Health. This manuscript was prepared using an OAI public use data set and does not necessarily reflect the opinions or views of the OAI investigators, the NIH, or the private funding partners.

References

1. Altman RD, Bloch DA, Dougados M, Hochberg M, Lohmander S, Pavelka K, et al. Measurement of structural progression in osteoarthritis of the hip: the Barcelona consensus group. Osteoarthritis Cartilage. 2004; 12:515–524. [PubMed: 15219566]
2. Vignon E, Conrozier T, Piperno M, Richard S, Carrillon Y, Fantino O. Radiographic assessment of hip and knee osteoarthritis. Recommendations: recommended guidelines. Osteoarthritis Cartilage. 1999; 7:434–436. [PubMed: 10419791]

3. FDA. Clinical Development Programs for Drugs, Devices and Biological Products Intended for the Treatment of OA. FDA; Washington: 1999.

4. Hunter DJ, Zhang YQ, Tu X, Lavalley M, Niu JB, Amin S, et al. Change in joint space width: hyaline articular cartilage loss or alteration in meniscus? Arthritis Rheum. 2006; 54:2488–2495. [PubMed: 16868968]

5. Guermazi A, Hunter DJ, FW R. Plain radiography and magnetic resonance imaging diagnostics in osteoarthritis: validated staging and scoring. J Bone Joint Surg Am. Suppl. 2009; 1:54–62. [PubMed: 19182026]

6. Chu Miow Lin D, Reichmann WM, Gossec L, Losina E, Conaghan PG, Maillefert JF. Validity and responsiveness of radiographic joint space width metric measurement in hip osteoarthritis: a systematic review. Osteoarthritis Cartilage. 2011; 19:543–549. [PubMed: 21396472]

7. Conrozier T, Lequesne M, Favret H, Taccoen A, Mazieres B, Dougados M, et al. Measurement of the radiological hip joint space width. An evaluation of various methods of measurement. Osteoarthritis Cartilage. 2001; 9:281–286. [PubMed: 11300752]

8. Vignon E. Radiographic issues in imaging the progression of hip and knee osteoarthritis. J Rheumatol Suppl. 2004; 70:36–44. [PubMed: 15132353]

9. Neumann G, Hunter D, Nevitt M, Chibnik LB, Kwoh K, Chen H, et al. Location specific radiographic joint space width for osteoarthritis progression. Osteoarthritis Cartilage. 2009; 17:761–765. [PubMed: 19073368]

10. Goker B, Doughan AM, Schnitzer TJ, Block JA. Quantification of progressive joint space narrowing in osteoarthritis of the hip: longitudinal analysis of the contralateral hip after total hip arthroplasty. Arthritis Rheum. 2000; 43:988–994. [PubMed: 10817550]

11. Khan AM, McLoughlin E, Giannakas K, Hutchinson C, Andrew JG. Hip osteoarthritis: where is the pain? Ann R Coll Surg Engl. 2004; 86:119–121. [PubMed: 15005931]

12. Traycoff RB. “Pseudotrochanteric bursitis”: the differential diagnosis of lateral hip pain. J Rheumatol. 1991; 18:1810–1812. [PubMed: 1665523]

13. Goker B, Sancak A, Arac M, Shott S, Block JA. The radiographic joint space width in clinically normal hips: effects of age, gender and physical parameters. Osteoarthritis Cartilage. 2003; 11:328–334. [PubMed: 12744938]

14. Lequesne M, Malghem J, Dion E. The normal hip joint space: variations in width, shape, and architecture on 223 pelvic radiographs. Ann Rheum Dis. 2004; 63:1145–1151. [PubMed: 15308525]

15. Chevalier X, Conrozier T, Gehrmann M, Claudepierre P, Mathieu P, Unger S, et al. Tissue inhibitor of metalloprotease-1 (TIMP-1) serum level may predict progression of hip osteoarthritis. Osteoarthritis Cartilage. 2001; 9:300–307. [PubMed: 11399093]

16. Conrozier T, Brandt K, Piperno M, Mathieu P, Merle-Vincent F, Vignon E. Reproducibility and sensitivity to change of a new method of computer measurement of joint space width in hip osteoarthritis. Performance of three radiographic views obtained at a 3-year interval. Osteoarthritis Cartilage. 2009; 17:864–870. [PubMed: 19138537]

17. Dougados M, Villers C, Amor B. Sensitivity to change of various roentgenological severity scoring systems for osteoarthritis of the hip. Rev Rhum Engl Ed. 1995; 62:169–173. [PubMed: 7788333]

18. Lequesne M, Maheu E, Cadet C, Dreiser RL. Structural effect of avocado/soybean unsaponifiables on joint space loss in osteoarthritis of the hip. Arthritis Rheum. 2002; 47:50–58. [PubMed: 11932878]

19. Rozendaal RM, Koes BW, van Osch GJ, Uitterlinden EJ, Garling EH, Willemsen SP, et al. Effect of glucosamine sulfate on hip osteoarthritis: a randomized trial. Ann Intern Med. 2008; 148:268–277. [PubMed: 18283204]

20. Husted JA, Cook RJ, Farewell VT, Gladman DD. Methods for assessing responsiveness: a critical review and recommendations. J Clin Epidemiol. 2000; 53:459–468. [PubMed: 10812317]

21. Lane NE, Nevitt MC, Hochberg MC, Hung YY, Palermo L. Progression of radiographic hip osteoarthritis over eight years in a community sample of elderly white women. Arthritis Rheum. 2004; 50:1477–1486. [PubMed: 15146417]

22. Maheu E, Cadet C, Marty M, Dougados M, Ghabri S, Kerloch I, et al. Reproducibility and sensitivity to change of various methods to measure joint space width in osteoarthritis of the hip: a

double reading of three different radiographic views taken with a three-year interval. Arthritis Res Ther. 2005; 7:R1375–1385. [PubMed: 16277690]

23. Maillefert JF, Sharp JT, Aho LS, Dougados M. Comparison of a computer based method and the classical manual method for radiographic joint space width assessment in hip osteoarthritis. J Rheumatol. 2002; 29:2592–2596. [PubMed: 12465158]
24. Pavelka K, Gatterova J, Gollerova V, Urbanova Z, Sedlackova M, Altman RD. A 5-year randomized controlled, double-blind study of glycosaminoglycan polysulphuric acid complex (Rumalon) as a structure modifying therapy in osteoarthritis of the hip and knee. Osteoarthritis Cartilage. 2000; 8:335–342. [PubMed: 10966839]

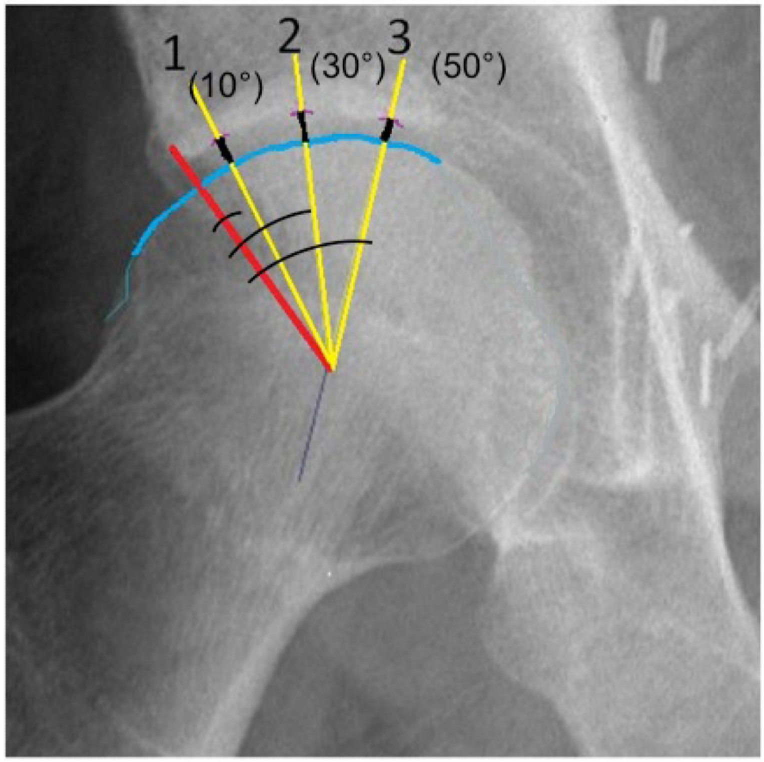

Figure 1.
Example of location-specific hip JSW measurement

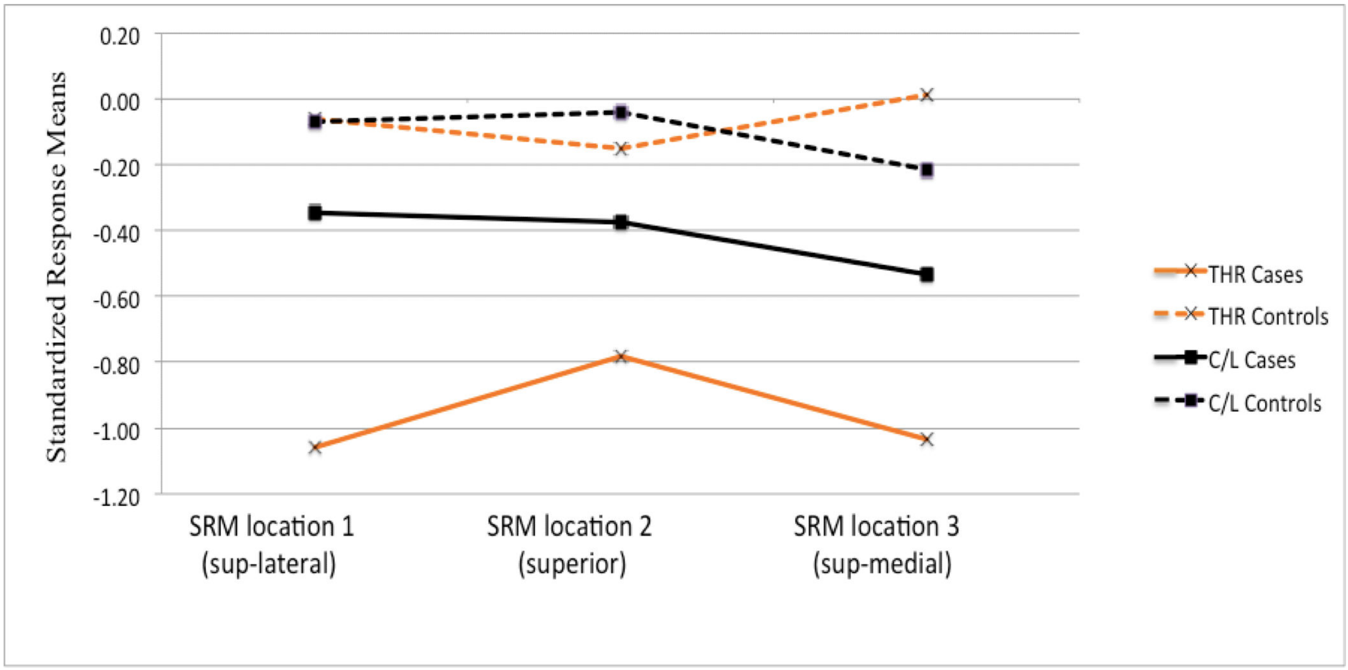

Figure 2.

Standardized Response Means in THR hips (and controls) and in contralateral hips of those receiving THR (and controls)

Table 1

Subject Characteristics

Characteristics	Hips that received THR after 48mos. OAI visit (n=27 hips)	Controls (n=27 hips)	p-value[2]	C/L hips (of those with THR any OAI visit) (n=79 hips)	Controls (n=79 hips)	p-value[2]
Age, *yr*	62.9 (8.7)	63.0 (8.9)	-	63.2 (8.6)	63.2 (8.7)	-
Sex[*]						
Male	12	12	-	32	32	-
Female	15	15		47	47	
BMI baseline	27.4	26.9	0.61	28.8	27.6	0.08
Ethnicity						
Caucasian	26	24	0.63[3]	69	72	0.63
Other	1	3		10	7	
[1]Baseline mJSW	2.89 (1.12)	3.48 (0.59)	**0.02**	3.35 (0.82)	3.48 (0,79)	0.36
Baseline JSW 1	5.05 (1.53)	5.23 (1.01)	0.63	5.11 (1.00)	5.36 (1.02)	0.15
Baseline JSW 2	4.85 (1.28)	5.24 (1.17)	0.26	5.20 (0.88)	5.21 (1.28)	0.96
Baseline JSW 3	4.80 (0.98)	4.66 (0.86)	0.59	4.98 (0.88)	4.90 (1.11)	0.56
4-year mJSW	1.89 (1.01)	3.52 (0.85)	**0.00**	3.12 (0.92)	3.46 (0.85)	**0.01**
4-year JSW 1	3.54 (1.77)	5.20 (1.01)	**0.00**	4.88 (1.08)	5.33 (1.03)	**0.01**
4-year JSW 2	3.59 (1.60)	5.16 (1.06)	**0.00**	4.97 (1.04)	5.18 (1.07)	0.21
4-year JSW 3	3.51 (1.26)	4.67 (0.86)	**0.00**	4.58 (1.03)	4.77 (1.08)	0.26
4-year Δ in mJSW	−1.18 (1.18)	0.06 (0.71)	**0.00**	−0.29 (0.81)	−0.01 (0.59)	**0.01**
4-year Δ in JSW 1	−1.51 (1.43)	−0.03 (0.53)	**0.00**	−0.23 (0.68)	−0.03 (0.46)	**0.02**
4-year Δ in JSW 2	−1.25 (1.60)	−0.08 (0.54)	**0.00**	−0.24 (0.63)	−0.03 (0.81)	0.10
4-year Δ in JSW 3	−1.29 (1.24)	0.01 (0.50)	**0.00**	−0.40 (0.75)	−0.13 (0.60)	**0.01**

[1]All JSW measures in mm

[2]From paired t-tests

[3]McNemars test

[*]Matched cases and controls

Table 2

4-year change (baseline to 48 month) in hip JSW in THR hips (and controls) and in contralateral hips of those receiving THR (and controls)

Group 1 (THR)	**Mean (sd) AmJSW (mm)**	**Mean (sd) AJSW 1 (sup-lat) (mm)**	**Mean (sd) AJSW 2 (superior) (mm)**	**Mean (sd) AJSW 3 (sup-med) (mm)**	**SRM mJSW**	**SRM Location 1 (sup-lat)**	**SRM Location 2 (superior)**	**SRM Location 3 (sup-med)**
THR Cases (n=27)	−1.18 (1.18)	−1.51 (1.42)	−1.25 (1.60)	−1.29 (1.24)	−1.00	−1.06	−0.78	−1.04
Controls (n=27)	0.06 (0.71)	−0.03 (0.53)	−0.08 (0.54)	0.01 (0.50)	0.08	−0.06	−0.15	0.02
p-value [1]	**0.000**	**0.000**	**0.001**	**0.000**				
Group 2 (Contralateral to THR)								
Cases (n=79)	−0.29 (0.81)	−0.23 (0.68)	−0.24 (0.63)	−0.40 (0.75)	−0.36	−0.34	−0.37	−0.53
Controls (n=79)	−0.02 (0.59)	−0.03 (0.46)	−0.03 (0.81)	−0.13 (0.60)	−0.03	−0.07	−0.04	−0.21
p-value [1]	**0.01**	**0.03**	0.07	**0.01**				

[1] From paired t-tests

Table 3

Baseline to 48 month change in JSW and SRM in contralateral hips of those receiving THR (n=79), by location, by pain status

Anterior hip or groin pain	Baseline mJSW	Baseline JSW 1	Baseline JSW 2	Baseline JSW 3	Mean 48m (sd) AmJSW	Mean 48m (sd) AJSW 1	Mean 48m (sd) AJSW 2	Mean 48m (sd) AJSW 3	SRM mJSW	SRM 1	SRM 2	SRM 3
Pain at ≥1 or more follow-ups (n=17)	3.22 (0.93)	5.06 (1.29)	5.29 (1.26)	5.18 (1.05)	−0.40 (0.63)	−0.58 (1.06)	−0.32 (1.06)	−0.90 (1.23)	0.63	−0.55	−0.30	−0.74
No hip pain 0-48 months (n=62)	3.48 (0.77)	5.12 (0.92)	5.17 (0.75)	4.93 (0.83)	−0.31 (0.75)	−0.14 (0.59)	−0.21 (0.46)	−0.26 (0.49)	0.42	−0.24	−0.46	−0.54
p-value[+]	0.25	0.82	0.63	0.31	0.67	**0.02**	0.55	**0.00**				

[+] from t-tests