# Injury


# Lack of Correlation between Hip Osteoarthritis and Anatomical Spinopelvic Parameters Obtained in Supine Position on MRI

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| **Abstract:** | Purpose: Hip osteoarthritis (HOA) is known to have a multifactorial pathogenesis. Recent studies suggest that spinopelvic alignment may represent an important additional pathogenic abnormality resulting in HOA. This study aims to assess the correlation between spinopelvic parameters (pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS) and lumbar lordosis (LL)) obtained in the supine position on MRI and HOA, lateral center edge (LCE) angle, and patient reported back pain.<br>Methods: Asymptomatic participants from the whole-body MRI cohort (FF4) from the cross-sectional case-control “Cooperative Health Research in the Region of Augsburg” study (KORA) were included. Whole-body MRI was performed in a standardized fashion in each case, on which hip osteoarthritis (HOA), anatomical spinopelvic parameters and lateral center edge angle were measured. Presence of back pain was assessed using a standardized questionnaire. Correlations were estimated by logistic regression models providing odds ratio.<br>Results: Among 340 subjects (mean age 56.3±9.3 years; 56.5% male), HOA was present in 89.1% (male: 87.0%, female: 91.7%, p=0.17). The LCE angle was 30.0° ± 5.5 (men: 29.8° ± 5.9; women: 30.1° ± 5.1; p=0.696). Mean PI was 54.0° ± 11.3°, PT was 13.7° ± 5.9°, SS was 40.3° ± 8.8° (significantly smaller in women p<0.05) and LL was 36.4° ± 9.6° (significantly greater in women p<0.05). None of the spinopelvic parameters correlated significantly with hip osteoarthritis or LCE angle. HOA was not correlated with back pain.<br>Conclusion: Spinopelvic parameters as measured in the supine position on MRI, do not correlate with hip osteoarthritis or lateral center edge angle. |
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Original Research

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# Lack of Correlation between Hip Osteoarthritis and Anatomical Spinopelvic Parameters Obtained in Supine Position on MRI

## Highlights

No correlation between spinopelvic parameters and hip osteoarthritis in supine MRI

Furthers knowledge about impact of spinopelvic parameters on musculoskeletal system

Helps to clarify the potential etiologies of hip osteoarthritis


## Abstract

**Purpose:** Hip osteoarthritis (HOA) is known to have a multifactorial pathogenesis. Recent studies suggest that spinopelvic alignment may represent an important additional pathogenic abnormality resulting in HOA. This study aims to assess the correlation between spinopelvic parameters (pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS) and lumbar lordosis (LL)) obtained in the supine position on MRI and HOA, lateral center edge (LCE) angle, and patient reported back pain.

**Methods:** Asymptomatic participants from the whole-body MRI cohort (FF4) from the cross-sectional case-control “Cooperative Health Research in the Region of Augsburg” study (KORA) were included. Whole-body MRI was performed in a standardized fashion in each case, on which hip osteoarthritis (HOA), anatomical spinopelvic parameters and lateral center edge angle were measured. Presence of back pain was assessed using a standardized questionnaire. Correlations were estimated by logistic regression models providing odds ratio.

**Results:** Among 340 subjects (mean age 56.3±9.3 years; 56.5% male), HOA was present in 89.1% (male: 87.0%, female: 91.7%, p=0.17). The LCE angle was 30.0° ± 5.5 (men: 29.8° ± 5.9; women: 30.1° ± 5.1; p=0.696). Mean PI was 54.0° ± 11.3°, PT was 13.7° ± 5.9°, SS was 40.3° ± 8.8° (significantly smaller in women p<0.05) and LL was 36.4° ± 9.6° (significantly greater in women p<0.05). None of the spinopelvic parameters correlated significantly with hip osteoarthritis or LCE angle. HOA was not correlated with back pain.

**Conclusion:** Spinopelvic parameters as measured in the supine position on MRI, do not correlate with hip osteoarthritis or lateral center edge angle.

**Key Words**: MRI; Osteoarthritis; Cohort Studies; Spinopelvic Alignment

## Introduction

Hip osteoarthritis (HOA), a degenerative joint disease with an age-dependent prevalence of up to 21.8%, negatively impacts quality of life due to restricted activity and disability [1, 2]. This HOA results in increased joint stiffness with accompanying pain both with use and at rest, resulting in substantial associated morbidity [3, 4].

A variety of risk factors are known to cause or hasten degenerative changes in joints, such as age and obesity [2, 3]. Recently, there has been mounting evidence that the position of the pelvis and the spine may also have a decisive influence on degenerative changes of the hip joint [5-7].

Changes of the pelvic-sacral posture affect the inclination of the pelvis in the sagittal plane. While a small pelvic tilt (PT) causes a forward inclination of the pelvis (pelvic anteversion), a pelvic retroversion is the consequence of large pelvic tilt (PT) [8]. Boulay and Yang demonstrated that the sacral slope (SS) is characterized by the pelvic incidence (PI), with small PI angles leading to a decrease in SS, resulting in a flattening of the lordosis of the lumbar spine (LL) [9, 10]. Vice versa, Yoshimoto et al. found that patients with total hip arthroplasty frequently show flexion contractures of the hip. These contractures in turn lead to anterior pelvic obliquity and a compensatory lordosis of the lumbar spine [6].

Although there is sufficient evidence in the literature documenting the coexistence of osteoarthritis of the hip joint and changes in the spinal column [7, 11], an underlying causative relationship has not been thoroughly investigated. Since the occurrence of hip osteoarthritis depends in part on the orientation and presence of dysplasia of the hip and acetabulum [12], which in turn is determined by the inclination of the pelvis [6], the junction between the pelvis, the sacrum and the spine may therefore have an important role in hip osteoarthritis [13]. Another potential risk factor for the development of hip osteoarthritis is the lateral center edge angle (LCE), since an over coverage might lead to an impingement of the hip (Pincer impingement) and thus promotes degenerative changes to the joint [14].

The aim of this study is to assess the correlation between spinopelvic parameters (PI, PT, SS, LL) obtained in supine position on MRI and hip osteoarthritis, lateral center edge angle, as well as back pain.

## Material & Methods

Study Design

Study subjects were selected from the second follow up FF4 (n=2279; 2013-2014) of the population based "Cooperative Health Research in the Region of Augsburg" (KORA; Kooperative Gesundheitsforschung in der Region Augsburg) with baseline examination (S4) during 1999-2001. In addition to standardized interviews and clinical examination at FF4, a subset of 400 participants underwent whole-body MRI; detailed study design with inclusion and exclusion criteria have been described previously [15-17].

Written approval was given by the institutional review board (IRB) [redacted]. Patients' written informed consent to participate in the study was provided.

Covariates

Body mass index (kg/m$^2$) was calculated for all study subjects.

The presence and severity of back pain was assessed during the second follow-up (FF4) with a standardized twofold questionnaire, which asked 1) if participants were suffering from back pain (Yes/No), and 2) if yes, how severe the pain was (none, little, moderate, strong, and very strong (single-choice question)).

MR Imaging Protocol

All participants underwent whole-body MR using a 3T scanner (Magnetom Skyra, Siemens Healthcare, Erlangen, Germany). Detailed description of the imaging protocol is described elsewhere [18]. Anatomical structures were assessed using a transversal dual-echo Dixon and a SS-FSE/HASTE sequence (coronal T2w single-shot fast spin echo). Imaging parameters were as follows: dual-echo Dixon: matrix: 256 x 256, field of view (FOV): 488 x 716 mm, echo time (TE): 1.26 ms and 2.49 ms, repetition time (TR): 4.06 ms, partition segments: 1.7 mm, flip angle: 9°; T2 HASTE: matrix: 320 x 200, field of view (FOV): 296 x 380 mm, TE: 91 ms, TR: 1000 ms, partition segments: 5 mm, flip angle: 131°. Prior to the MR examination, all included participants were positioned on the exam table using a standardized protocol. Positioning protocol: centered on the exam table in supine position, parallel and slightly bent legs, arms parallel to the body. If misalignment of the pelvic region was present after initial positioning, 3D multi-planar reconstruction was used to align the axis via a perpendicular line through both centers of the femoral head [16].

## Spinopelvic Parameters

As defined by During and Duval-Beaupere, the spinopelvic balance consists of a morphologically present parameter (pelvic incidence), and three functionally adaptable parameters (sacral slope, pelvic tilt, and lumbar lordosis) [16, 19, 20].

### *Pelvic Incidence*

Pelvic incidence (PI) is measured in the sagittal plane and is defined as the angle between a plumb vertical line and a second line running from the midpoint of the upper plate of the S1 vertebra to the center of the femoral head axis (**Figure 1(a)**) [16, 21, 22]. In addition, the pelvic incidence is the sum of sacral slope and pelvic tilt (PI = SS + PT); which are based on geometric associations described in detail below [21]. Standard values of PI in the upright position are 53.1 ± 9.0°, which does not differ by gender [9].

### *Pelvic Tilt*

Pelvic tilt (PT) is measured in the sagittal plane and is defined as the as the angle between a vertical line and a line connecting the midpoint of the femoral head to the midpoint of the sacral plateau (**Figure 1(b)**). The standard values of PT in the upright position are 13 ± 6° [16, 23].

### *Sacral Slope*

Sacral slop (SS) is defined in the sagittal plane as the angle between a horizontal line and a second line running parallel to the sacral plateau (**Figure 1(c)**) [23]. SS is considered the foundation of the spinal column [9, 16, 21, 24]. Standard values of SS in the upright position are 41 ± 8° [25].

### *Lumbar Lordosis*

Lumbar lordosis is defined in the sagittal plane as the angle between a line parallel to the superior endplate of the L1 vertebral body and a second line parallel to the inferior endplate of the L5 vertebral body [10, 16, 24]. Standard values of LL in the upright position are 44 ± 11° [25].

Lateral Center Edge Angle (LCE)

Lateral edge angle is a measure of bony femoral head coverage and is defined as the angle between a vertical line drawn from the center of the femoral head and a second line connecting the center of the femoral head and the lateral acetabulum rim (**Figure 2**) [26, 27].

Hip Osteoarthritis (HOA)

An osteoarthritis (OA) MRI score based on the Kellgren-Lawrence classification (**Table 1**) which incorporates subchondral sclerosis, osteophytes and width of the joint space was used to quantify hip osteoarthritis (**Figure 3**). The sum of each category was used to classify osteoarthritic severity into one of 5 grades: *Grade 0* = 0 points (**Figure 3a**); *Grade 1* = 1-2 point(s) (**Figure 3b**); *Grade 2* = 3-4 points (**Figure 3c**); *Grade 3* = 5-7 points (**Figure 3d**) and *Grade 4* = 8 points. Grades 1 to 4 were defined as pathological [17].

Image Analysis

Image analysis of all datasets was performed in a blinded and randomized fashion by two independent readers with 6 years (radiologist) and 7 years (trauma surgeon) of experience in musculoskeletal imaging. Six weeks after the first read-out, the primary reader (radiologist) re-evaluated 40 randomly selected datasets to assess intra-reader agreement.

Using Bland-Altman analysis the inter-reader (-0.3% (PI), 1.1% (SS), -1.4% (PT), 0.5% (LL)) and intra-reader (-0.5% (PI), 0.2% (SS), -0.5% (PT), -1.4% (LL)) agreement of the spinopelvic parameters revealed mean relative differences of less than 5% for all parameters, as well as an intraclass correlation (ICC) of more than 0.95 (inter: 0.99 (PI), 0.99 (SS), 0.98 (PT), 0.99 (LL); intra: 0.99 (PI), 0.99 (SS), 0.98 (PT), 0.99 (LL)).

The inter-reader agreement for hip osteoarthritis was K=0.94 (right) and K=0.88 (left). Agreement for HOA MRI score was K=0.86 (right) and K=0.9 (left) for inter-reader analysis, and K=0.97 (right) and K=0.96 (left) for intra-reader analysis.

Inter- and intra-reader agreement analysis of LCE parameters (right, left) revealed mean relative differences according to Bland-Altman analyses of <5% for all parameters (inter: -2.4%, -0.7%; intra: -1.5%, -1.2%; respectively) and ICC values >0.95 (inter: 0.98, 0.97; intra: 0.98, 0.97; respectively).

## Statistical Analysis

Descriptive parameters of study participants are given as means and standard deviations (SD) for continuous variables and as counts and percentages for categorical variables. Statistical analysis of continuous variables and categorical variables was conducted using Student's t-test and $chi^2$-test, respectively.

Linear regression models providing β-coefficients with 95% confidence intervals (CI) were used to evaluate associations between spinopelvic parameters and LCE. Logistic regression models providing odds ratios (OR) with 95% CI were used to evaluate associations between spinopelvic parameters and HOA MRI. Models were applied separately for the left and right body side and for women and men. Multivariable adjustment included the potential confounder variables age, sex, BMI, hypertension, total cholesterol, HDL-C, triglycerides, diabetes status and physical activity; a detailed description of the assessment and cut-off values are described elsewhere [15]. Distribution differences of spinopelvic parameters between participants with and without HOA were displayed graphically by histograms.

Associations of LCE and HOA parameters with dichotomized and categorical back pain were separately assessed using logistic and ordered logistic regression models. All models were adjusted for the same co-variables as mentioned above.

A p-value of <0.05 was considered statistically significant. All analyses were conducted using Stata 16.1 (Stata Corporation, College Station, TX, U.S.A.).

## Results

General results

In total, 340 of the initial 400 participants were included in this study; 60 potential participants were excluded due to poor image quality (n=12), incomplete study (n=24), uni- or bilateral hip prostheses (n=8), and missing or incomplete laboratory parameters (n=16) (**Figure 4**).

The mean age of the cohort was 56.3 ± 9.3 years (56.5% male) with a mean BMI of 27.8 ± 4.9 kg/m$^2$. Hip osteoarthritis was present in 89.1% of the participants, without significant difference between sexes (p=0.17). The lateral center edge angle was 30.0° ± 5.5° (men: 29.8° ± 5.9° and women: 30.1° ± 5.1°; p=0.696).

The mean spinopelvic parameters were 54.0° ± 11.3° for PI, 13.7° ± 5.9° for PT, 40.3° ± 8.8° for SS and 36.4° ± 9.6° for LL. LL was significantly lower in men (men: 35.0° ± 9.2° and women: 38.1° ± 9.9°; p<0.05), while SS was significantly lower in women (men:  41.2° ± 8.2° and women: 39.2° ± 9.3°; p<0.05). Detailed demographic, hip, and spinopelvic parameters are shown in **Table 2**.

Multivariate analysis, adjusted for age, gender, BMI, hypertension, diabetes mellitus, and physical activity, did not show any correlation between spinopelvic parameters and hip osteoarthritis or lateral center edge angle (**Table 3**).

There was no observed correlation between spinopelvic parameters and the presence or absence of osteoarthritis of the hip (**Figure 5**).

There was no correlation between HOA MRI Score, LCE angle and back pain (**Table 4**).

## Discussion

This study investigated the correlation of spinopelvic parameters and hip osteoarthritis gathered from supine whole-body MRI. The results demonstrated that none of the spinopelvic parameters (pelvic incidence, pelvic tilt, sacral slope or lumbar lordosis) influenced hip osteoarthritis significantly within the observed cohort. No significant correlation was observed between spinopelvic parameters and the LCE angle, nor between HOA or LCE angle and back pain. Gender influenced neither HOA nor LCE angle.

It is well-known that severe hip osteoarthritis impairs the hip joint's mobility, which primarily compromises hip extension due to a flexion contracture [28, 29]. In order to compensation, forced anteversion of the pelvis occurs, which in turn causes an increase in lumbar lordosis [6, 30]. This subsequently worsens the shear force on the spinal facet joints and may results in back pain [30, 31]. Additionally, an increasing PI leads to a posterior tilt of the pelvis, which in turn reduces the coverage of the femoral head. Continuous improper loading and increased shear of the femoral head on normally non-weight-bearing sections of the acetabulum can result in the development of dysplasia, which may be the basis for HOA [5].

Despite the theoretical importance of spinopelvic geometry on orthopedic pathology, literature investigating the associations between the spinopelvic alignment and hip osteoarthritis is rare. Gebhart et al. found in a cadaver study that a higher PI at a younger age was associated with secondary HOA at an older age, while there was no significant association between a small PI and HOA. It was emphasized that a small PI is not necessarily protective [5]. Similar results were shown by Yoshimoto et al. who demonstrated that PI was greater in patients with HOA compared to those with lower back pain and no HOA, and therefore suggested that larger PI values in young age may cause HOA in old age. However, their age and gender matched control group had surgery-worthy pathologies of the lower spine along with low back pain [6]. In contrast, Raphael et al. did not show any difference in PI between patients with moderate to serve HOA compared to those without HOA assessed using CT scans [32]. This is in line with the findings of this study, proving that there was no correlation between PI and HOA obtained in supine position on MRI. Also, Weng et al. and Sariali et al. found that PI in patients with and without HOA was similar [33, 34]. Nevertheless, their results diverge in terms of sacral slope showing a significant higher SS and smaller PT [33] and a lower SS [34] in patients with hip osteoarthritis. It may be surmised that these differences were due to the respective selection of the control group; however, when considering patients with HOA both with and without lower back pain, there was no difference in spinopelvic parameters [33]. Contrary to Yoshimoto's hypothesis, Weng suggested that the spinopelvic alignment is not involved in the pathogenesis of HOA. This is supported by a meta-analysis (2017), which showed that the impact of PI on HOA remains inconclusive [35].

While PI is similar in patients with rapid destructive coxarthrosis (RDC) and HOA, LL and SS were significantly lower, yet PT was significantly larger in case of RDC [35]. The consequence of an increased PT or decreased SS is retroversion of the pelvis [8, 23]. Data supporting this association was observed by Innmann et al., who found greater posterior tilt of the pelvis in the seated position and suggested that this might be due to reduced hip flexion in HOA [36]. Retroversion of the pelvis was shown to decrease once total hip arthroplasty was performed, but the sacral slope did not return to the normal range [34]. Despite this, the literature regarding the influence of HOA on pelvic inclination remains controversial [6, 33, 34, 36]. In the present cohort, HOA did not influence PT. Okuda et al. showed in their cross-sectional study that healthy patients undergo a decrease in SS with age, leading to a retroversion of the pelvis [37]. This is not consistent with the findings, published in a previous study, showing no change in SS with age [16].

Symptomatic femoroacetabular impingement (FAI), as well as the center gab, the distance between the rotation center of the acetabulum and the femoral head, have been shown to be important parameters in the development of hip osteoarthritis [14, 38, 39]. However, it remains unclear how clinically asymptomatic under- and overcoverage of the acetabulum affects the development of hip osteoarthritis. In this regard, Hoch et al. found that an alpha angle of more than 55 degrees, defined as CAM impingement, was a significant risk factor for the development of HOA, whereas angles less than 20 to 25 degrees did not significantly increase risk. However, it was emphasized that, in addition to impingement, physical activity and symptomatology are also important contributing factors [14]. Impingement leads to shear forces, which in turn cause abrasion of the acetabular cartilage in the anterosuperior rim [39]. No correlation between LCE angle and hip osteoarthritis was found in the present study.

Chronic back pain is a common health issue worldwide and is the chief contributor to “years lived with a disability” [40, 41]. Several individual, psychosocial, and occupational parameters are known to both initiate and sustain back pain [42]. It remains unclear to what extent hip osteoarthritis might cause back pain in addition to characteristic hip pain. Prather et al. found that 84% of patients examined with low back pain presented a pathology of the hip joint (e.g., HOA, hip dysplasia or FAI), while HOA only accounted for 20%. Both Prather et al. [43] and Weng et al. [33] found that HOA was not significantly associated with lower back pain, which is in line with the findings of this study. The studies additionally observed a significant association between FAI and lower back pain [43]. This is contrary to the findings of the present study, as there was no observed correlation between back pain and LCE angle.

This study has several limitations. First, anatomical spinopelvic parameters were assessed on MRI in supine position. Although there is some controversy in the literature [44], it has been shown that comparable results can be obtained by standardized, accurate positioning of the patient, including in the supine position [45]. Furthermore, the limited follow-up period represents another limitation. MRI exams were only performed at FF4, which is why long-term outcomes cannot be assessed making this study cross-sectional. The KORA MRI study has an extensive imaging protocol with various body regions (e.g., heart, brain, liver, anatomical structures, …), which results in long scan times. To reduce overall scan times for participants, structures and organs were acquired in less detail than in organ-specific studies, resulting in decreased image quality versus dedicated imaging. However, image quality was sufficient for the purposes of this study.

## Conclusion

Spinopelvic parameters as measured in the supine position on MRI, do not correlate with hip osteoarthritis or lateral center edge angle.

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## References

[1] A. Postler, A.L. Ramos, J. Goronzy, K.P. Gunther, T. Lange, J. Schmitt, A. Zink, F. Hoffmann, Prevalence and treatment of hip and knee osteoarthritis in people aged 60 years or older in Germany: an analysis based on health insurance claims data, Clin Interv Aging 13 (2018) 2339-2349 DOI: 10.2147/CIA.S174741.
[2] Y.M. Zhang, J. Wang, X.G. Liu, Association between hypertension and risk of knee osteoarthritis: A meta-analysis of observational studies, Medicine (Baltimore) 96(32) (2017) e7584 DOI: 10.1097/MD.0000000000007584.
[3] G. Schett, A. Kleyer, C. Perricone, E. Sahinbegovic, A. Iagnocco, J. Zwerina, R. Lorenzini, F. Aschenbrenner, F. Berenbaum, M.A. D'Agostino, J. Willeit, S. Kiechl, Diabetes is an independent predictor for severe osteoarthritis: results from a longitudinal cohort study, Diabetes Care 36(2) (2013) 403-9 DOI: 10.2337/dc12-0924.
[4] G.A. Hawker, R. Croxford, A.S. Bierman, P. Harvey, B. Ravi, T. Kendzerska, I. Stanaitis, L.K. King, L. Lipscombe, Osteoarthritis-related difficulty walking and risk for diabetes complications, Osteoarthritis Cartilage 25(1) (2017) 67-75 DOI: 10.1016/j.joca.2016.08.003.
[5] J.J. Gebhart, D.S. Weinberg, M.S. Bohl, R.W. Liu, Relationship between pelvic incidence and osteoarthritis of the hip, Bone Joint Res 5(2) (2016) 66-72 DOI: 10.1302/2046-3758.52.2000552.
[6] H. Yoshimoto, S. Sato, T. Masuda, T. Kanno, M. Shundo, T. Hyakumachi, Y. Yanagibashi, Spinopelvic alignment in patients with osteoarthrosis of the hip: a radiographic comparison to patients with low back pain, Spine (Phila Pa 1976) 30(14) (2005) 1650-7 DOI: 10.1097/01.brs.0000169446.69758.fa.
[7] D. Phan, S.S. Bederman, R. Schwarzkopf, The influence of sagittal spinal deformity on anteversion of the acetabular component in total hip arthroplasty, Bone Joint J 97-B(8) (2015) 1017-23 DOI: 10.1302/0301-620X.97B8.35700.
[8] X. Wei, L. Gengwu, C. Chao, L. Yifan, S. Shang, H. Ruixi, J. Yunhan, Z. Xiaodong, L. Zhikun, Correlations between the sagittal plane parameters of the spine and pelvis and lumbar disc degeneration, J Orthop Surg Res 13(1) (2018) 137 DOI: 10.1186/s13018-018-0838-6.
[9] C. Boulay, C. Tardieu, J. Hecquet, C. Benaim, B. Mouilleseaux, C. Marty, D. Prat-Pradal, J. Legaye, G. Duval-Beaupere, J. Pelissier, Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis, Eur Spine J 15(4) (2006) 415-22 DOI: 10.1007/s00586-005-0984-5.
[10] X. Yang, Q. Kong, Y. Song, L. Liu, J. Zeng, R. Xing, The characteristics of spinopelvic sagittal alignment in patients with lumbar disc degenerative diseases, Eur Spine J 23(3) (2014) 569-75 DOI: 10.1007/s00586-013-3067-z.
[11] M.J. McNamara, K.G. Barrett, M.J. Christie, D.M. Spengler, Lumbar spinal stenosis and lower extremity arthroplasty, The Journal of Arthroplasty 8(3) (1993) 273-277 DOI: 10.1016/s0883-5403(06)80089-6.
[12] S. Jacobsen, Adult hip dysplasia and osteoarthritis, Acta Orthopaedica 77(sup324) (2010) 2-37 DOI: 10.1080/17453690610046505.
[13] C. Riviere, S. Lazic, L. Dagneaux, C. Van Der Straeten, J. Cobb, S. Muirhead-Allwood, Spine-hip relations in patients with hip osteoarthritis, EFORT Open Rev 3(2) (2018) 39-44 DOI: 10.1302/2058-5241.3.170020.
[14] A. Hoch, P. Schenk, T. Jentzsch, S. Rahm, P.O. Zingg, FAI morphology increases the risk for osteoarthritis in young people with a minimum follow-up of 25 years, Arch Orthop Trauma Surg 141(7) (2021) 1175-1181 DOI: 10.1007/s00402-020-03522-3.
[15] R. Holle, M. Happich, H. Lowel, H.E. Wichmann, M.K.S. Group, KORA--a research platform for population based health research, Gesundheitswesen 67 Suppl 1 (2005) S19-25 DOI: 10.1055/s-2005-858235.
[16] S.S. Walter, R. Lorbeer, G. Hefferman, C.L. Schlett, A. Peters, S. Rospleszcz, K. Nikolaou, F. Bamberg, M. Notohamiprodjo, E. Maurer, Correlation between thoracolumbar disc degeneration and anatomical spinopelvic parameters in supine position on MRI, PLoS One 16(6) (2021) e0252385 DOI: 10.1371/journal.pone.0252385.

[17] S.S. Walter, E. Wintermeyer, C. Klinger, R. Lorbeer, W. Rathmann, A. Peters, C.L. Schlett, B. Thorand, S. Gatidis, K. Nikolaou, F. Bamberg, M. Notohamiprodjo, Association between metabolic syndrome and hip osteoarthritis in middle-aged men and women from the general population, PLoS One 15(3) (2020) e0230185 DOI: 10.1371/journal.pone.0230185.
[18] F. Bamberg, H. Hetterich, S. Rospleszcz, R. Lorbeer, S.D. Auweter, C.L. Schlett, A. Schafnitzel, C. Bayerl, A. Schindler, T. Saam, K. Muller-Peltzer, W. Sommer, T. Zitzelsberger, J. Machann, M. Ingrisch, S. Selder, W. Rathmann, M. Heier, B. Linkohr, C. Meisinger, C. Weber, B. Ertl-Wagner, S. Massberg, M.F. Reiser, A. Peters, Subclinical Disease Burden as Assessed by Whole-Body MRI in Subjects With Prediabetes, Subjects With Diabetes, and Normal Control Subjects From the General Population: The KORA-MRI Study, Diabetes 66(1) (2017) 158-169 DOI: 10.2337/db16-0630.
[19] G. Duval-Beaupere, C. Schmidt, P. Cosson, A Barycentremetric study of the sagittal shape of spine and pelvis: the conditions required for an economic standing position, Ann Biomed Eng 20(4) (1992) 451-62 DOI: 10.1007/BF02368136.
[20] J. During, H. Goudfrooij, W. Keessen, T.W. Beeker, A. Crowe, Toward standards for posture. Postural characteristics of the lower back system in normal and pathologic conditions, Spine (Phila Pa 1976) 10(1) (1985) 83-7.
[21] J. Legaye, G. Duval-Beaupere, J. Hecquet, C. Marty, Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves, Eur Spine J 7(2) (1998) 99-103 DOI: 10.1007/s005860050038.
[22] V.A. Mehta, A. Amin, I. Omeis, Z.L. Gokaslan, O.N. Gottfried, Implications of spinopelvic alignment for the spine surgeon, Neurosurgery 70(3) (2012) 707-21 DOI: 10.1227/NEU.0b013e31823262ea.
[23] J.C. Le Huec, S. Aunoble, L. Philippe, P. Nicolas, Pelvic parameters: origin and significance, Eur Spine J 20 Suppl 5 (2011) 564-71 DOI: 10.1007/s00586-011-1940-1.
[24] C. Barrey, J. Jund, O. Noseda, P. Roussouly, Sagittal balance of the pelvis-spine complex and lumbar degenerative diseases. A comparative study about 85 cases, Eur Spine J 16(9) (2007) 1459-67 DOI: 10.1007/s00586-006-0294-6.
[25] F. Vollner, J. Grifka, [Biomechanical aspects of preoperative planning: What is really important?], Orthopade 48(1) (2019) 44-49 DOI: 10.1007/s00132-018-03673-7.
[26] J.D. Wylie, A.L. Kapron, C.L. Peters, S.K. Aoki, T.G. Maak, Relationship Between the Lateral Center-Edge Angle and 3-Dimensional Acetabular Coverage, Orthop J Sports Med 5(4) (2017) 2325967117700589 DOI: 10.1177/2325967117700589.
[27] P. Henle, M. Tannast, K.A. Siebenrock, [Imaging in developmental dysplasia of the hip], Orthopade 37(6) (2008) 525-31 DOI: 10.1007/s00132-008-1235-3.
[28] L.M. Day, E.M. DelSole, B.M. Beaubrun, P.L. Zhou, J.Y. Moon, J.C. Tishelman, J.M. Vigdorchik, R. Schwarzkopf, R. Lafage, V. Lafage, T. Protopsaltis, A.J. Buckland, Radiological severity of hip osteoarthritis in patients with adult spinal deformity: the effect on spinopelvic and lower extremity compensatory mechanisms, Eur Spine J 27(9) (2018) 2294-2302 DOI: 10.1007/s00586-018-5509-0.
[29] A.J. Buckland, L. Steinmetz, P. Zhou, D. Vasquez-Montes, M. Kingery, N.D. Stekas, E.W. Ayres, C.G. Varlotta, V. Lafage, R. Lafage, T. Errico, P.G. Passias, T.S. Protopsaltis, J. Vigdorchik, Spinopelvic Compensatory Mechanisms for Reduced Hip Motion (ROM) in the Setting of Hip Osteoarthritis, Spine Deform 7(6) (2019) 923-928 DOI: 10.1016/j.jspd.2019.03.007.
[30] C.M. Offierski, I. MacNab, Hip-spine syndrome, Spine (Phila Pa 1976) 8(3) (1983) 316-21 DOI: 10.1097/00007632-198304000-00014.
[31] A. Piazzolla, G. Solarino, D. Bizzoca, V. Montemurro, P. Berjano, C. Lamartina, C. Martini, B. Moretti, Spinopelvic parameter changes and low back pain improvement due to femoral neck anteversion in patients with severe unilateral primary hip osteoarthritis undergoing total hip replacement, Eur Spine J 27(1) (2018) 125-134 DOI: 10.1007/s00586-017-5033-7.
[32] I.J. Raphael, M.R. Rasouli, C.K. Kepler, S. Restrepo, T.J. Albert, K.E. Radcliff, Pelvic Incidence in Patients with Hip Osteoarthritis, Arch Bone Jt Surg 4(2) (2016) 132-6.
[33] W.J. Weng, W.J. Wang, M.D. Wu, Z.H. Xu, L.L. Xu, Y. Qiu, Characteristics of sagittal spine-pelvis-leg alignment in patients with severe hip osteoarthritis, Eur Spine J 24(6) (2015) 1228-36 DOI: 10.1007/s00586-014-3700-5.

[34] E. Sariali, J.Y. Lazennec, F. Khiami, M. Gorin, Y. Catonne, Modification of pelvic orientation after total hip replacement in primary osteoarthritis, Hip Int 19(3) (2009) 257-63 DOI: 10.1177/112070000901900312.
[35] T. Morimoto, M. Kitajima, M. Tsukamoto, T. Yoshihara, M. Sonohata, M. Mawatari, Sagittal spino-pelvic alignment in rapidly destructive coxarthrosis, Eur Spine J 27(2) (2018) 475-481 DOI: 10.1007/s00586-017-5282-5.
[36] M.M. Innmann, C. Merle, P. Phan, P.E. Beaule, G. Grammatopoulos, Differences in Spinopelvic Characteristics Between Hip Osteoarthritis Patients and Controls, J Arthroplasty (2021) DOI: 10.1016/j.arth.2021.03.031.
[37] T. Okuda, T. Fujita, A. Kaneuji, K. Miaki, Y. Yasuda, T. Matsumoto, Stage-specific sagittal spinopelvic alignment changes in osteoarthritis of the hip secondary to developmental hip dysplasia, Spine (Phila Pa 1976) 32(26) (2007) E816-9 DOI: 10.1097/BRS.0b013e31815ce695.
[38] M. Beck, M. Kalhor, M. Leunig, R. Ganz, Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip, J Bone Joint Surg Br 87(7) (2005) 1012-8 DOI: 10.1302/0301-620X.87B7.15203.
[39] R. Ganz, J. Parvizi, M. Beck, M. Leunig, H. Notzli, K.A. Siebenrock, Femoroacetabular impingement: a cause for osteoarthritis of the hip, Clin Orthop Relat Res (417) (2003) 112-20 DOI: 10.1097/01.blo.0000096804.78689.c2.
[40] G.B.D. Disease, I. Injury, C. Prevalence, Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015, Lancet 388(10053) (2016) 1545-1602 DOI: 10.1016/S0140-6736(16)31678-6.
[41] C.J. Murray, A.D. Lopez, Measuring the global burden of disease, N Engl J Med 369(5) (2013) 448-57 DOI: 10.1056/NEJMra1201534.
[42] B.W. Koes, M.W. van Tulder, S. Thomas, Diagnosis and treatment of low back pain, BMJ 332(7555) (2006) 1430-4 DOI: 10.1136/bmj.332.7555.1430.
[43] H. Prather, A. Cheng, K. Steger-May, V. Maheshwari, L. VanDillen, Association of Hip Radiograph Findings With Pain and Function in Patients Presenting With Low Back Pain, PM R 10(1) (2018) 11-18 DOI: 10.1016/j.pmrj.2017.06.003.
[44] Z. Habibi, F. Maleki, A.T. Meybodi, A. Mahdavi, H. Saberi, Lumbosacral sagittal alignment in association to intervertebral disc diseases, Asian Spine J 8(6) (2014) 813-9 DOI: 10.4184/asj.2014.8.6.813.
[45] M.L. Andreasen, L. Langhoff, T.S. Jensen, H.B. Albert, Reproduction of the lumbar lordosis: a comparison of standing radiographs versus supine magnetic resonance imaging obtained with straightened lower extremities, J Manipulative Physiol Ther 30(1) (2007) 26-30 DOI: 10.1016/j.jmpt.2006.11.009.

# Conflict of Interest Statement

Manuscript title:

**Lack of Correlation between Hip Osteoarthritis and Anatomical Spinopelvic Parameters Obtained in Supine Position on MRI**

The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

The authors state that there is no conflict of interests.

## Abstract

**Purpose:** Hip osteoarthritis (HOA) is known to have a multifactorial pathogenesis. Recent studies suggest that spinopelvic alignment may represent an important additional pathogenic abnormality resulting in HOA. This study aims to assess the correlation between spinopelvic parameters (pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS) and lumbar lordosis (LL)) obtained in the supine position on MRI and HOA, lateral center edge (LCE) angle, and patient reported back pain.

**Methods:** Asymptomatic participants from the whole-body MRI cohort (FF4) from the cross-sectional case-control "Cooperative Health Research in the Region of Augsburg" study (KORA) were included. Whole-body MRI was performed in a standardized fashion in each case, on which hip osteoarthritis (HOA), anatomical spinopelvic parameters and lateral center edge angle were measured. Presence of back pain was assessed using a standardized questionnaire. Correlations were estimated by logistic regression models providing odds ratio.

**Results:** Among 340 subjects (mean age 56.3±9.3 years; 56.5% male), HOA was present in 89.1% (male: 87.0%, female: 91.7%, $p=0.17$). The LCE angle was 30.0° ± 5.5 (men: 29.8° ± 5.9; women: 30.1° ± 5.1; $p=0.696$). Mean PI was 54.0° ± 11.3°, PT was 13.7° ± 5.9°, SS was 40.3° ± 8.8° (significantly smaller in women $p<0.05$) and LL was 36.4° ± 9.6° (significantly greater in women $p<0.05$). None of the spinopelvic parameters correlated significantly with hip osteoarthritis or LCE angle. HOA was not correlated with back pain.

**Conclusion:** Spinopelvic parameters as measured in the supine position on MRI, do not correlate with hip osteoarthritis or lateral center edge angle.


**Key Words**: MRI; Osteoarthritis; Cohort Studies; Spinopelvic Alignment

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**Prof. Dr. P. V. Giannoudis**
Editor-in-Chief
***Injury***

**Manuscript Submission** 05/25/2022

Dear Prof. Dr. P.V. Giannoudis,

We would like to submit the research article

"**Lack of Correlation between Hip Osteoarthritis and Anatomical Spinopelvic Parameters Obtained in Supine Position on MRI**"

for publication as an original article in Injury.

In the present study, we aimed to investigate the correlation between spinopelvic parameters (pelvic incidence, pelvic tilt, sacral slope and lumbar lordosis) obtained in the supine position on MRI and hip osteoarthritis, lateral center edge angle, and patient reported back pain. The spinopelvic parameters, lateral center edge angle and hip osteoarthritis were evaluated in whole-body MRIs at 3 Tesla.
Our results indicated that spinopelvic parameters are not significantly correlated with neither hip osteoarthritis nor back pain. Consequently, spinopelvic parameters are unlikely to be directly involved in the pathogenesis of hip osteoarthritis or back pain.

Each of the authors can legitimately claim authorship. Each author has read and approved the submitted manuscript. None of the authors has a conflict of interest to report. The manuscript is not under consideration and has also not been published elsewhere. We would be very grateful if you would consider this work for publication in Injury.

With kind regards,

Dr. Sven Stephan Walter, on behalf of the authors

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**Table 1.** Osteoarthritis (OA) MRI score based on the Kellgren-Lawrence classification.

| OA MRI Score [17] | | |
|---|---|---|
| Subchondral sclerosis | None | 0 |
| | Little | 1 |
| | Moderate with cysts | 2 |
| | Heavy with cysts | 3 |
| Osteophytes | None | 0 |
| | Small | 1 |
| | Large | 2 |
| Mean gap of the hip joint cranially and medially (in mm) | None/ questionable [≥4 mm] | 0 |
| | Narrowing [2-4 mm] | 1 |
| | Heavy narrowing [0.1-2 mm] | 2 |
| | Loss of joint gap [0 mm] | 3 |

**Table 2.** Descriptive demographics, spinopelvic parameters, and degree of observed hip osteoarthritis of the study sample.

| **Characteristics** | **All** N=340 | **Women** N=156 | **Men** N=184 | p |
|---|---|---|---|---|
| Age (years) | 56.3 (±9.3) | 56.5 (±9.0) | 56.2 (±9.5) | 0.75 |
| BMI (kg/m$^2$) | 27.8 (±4.9) | 27.4 (±5.5) | 28.1 (±4.3) | 0.19 |
| Physical activity | 205 (60.3%) | 103 (66%) | 102 (55.4%) | **0.047** |
| Back pain | 186 (54.7%) | 84 (53.9%) | 102 (55.4%) | 0.77 |
| Pelvic incidence (°) | 54.0 (±11.3) | 53.0 (±12.3) | 54.8 (±10.4) | 0.14 |
| Pelvic tilt (°) | 13.7 (±5.9) | 13.8 (±6.5) | 13.6 (±5.3) | 0.76 |
| Sacral slope (°) | 40.3 (±8.8) | 39.2 (±9.3) | 41.2 (±8.2) | **0.04** |
| Lumbar lordosis (°) | 36.4 (±9.6) | 38.1 (±9.9) | 35.0 (±9.2) | **0.003** |
| Lateral center edge angle | | | | |
| mean | 30.0 (±5.5) | 29.8 (±5.9) | 30.1 (±5.1) | 0.70 |
| left | 29.2 (±5.6) | 29.0 (±5.9) | 29.4 (±5.4) | 0.59 |
| right | 30.7 (±6.0) | 30.6 (±6.6) | 30.8 (±5.5) | 0.84 |
| Hip osteoarthritis | | | | |
| overall | 303 (89.1%) | 143 (91.7%) | 160 (87%) | 0.17 |
| left | 285 (83.8%) | 136 (87.2%) | 149 (81%) | 0.12 |
| right | 277 (81.5%) | 133 (85.3%) | 144 (78.3%) | 0.10 |
| OA MRI Score | | | | |
| Left | | | | 0.12 |
| Grade 0 | 55 (16.2%) | 20 (12.8%) | 35 (19%) | |
| Grade 1 | 264 (77.7%) | 123 (78.9%) | 141 (76.6%) | |
| Grade 2 | 21 (6.2%) | 13 (8.3%) | 8 (4.4%) | |
| Right | | | | 0.11 |
| Grade 0 | 63 (18.5%) | 23 (14.7%) | 40 (21.7%) | |
| Grade 1 | 261 (76.8%) | 122 (78.2%) | 139 (75.5%) | |
| Grade 2 | 15 (4.4%) | 10 (6.4%) | 5 (2.7%) | |
| Grade 3 | 1 (0.3%) | 1 (0.6%) | 0 (0%) | |

Data are given as mean ± standard deviation or number (percentage); p-values are from t-test or chi$^2$-test

**Table 3.** Multivariable associations of spinopelvic parameters with HOA and LCE.

| | Hip Degeneration (HOA) - overall | | Left | | Right | | Women | | Men | |
|---|---|---|---|---|---|---|---|---|---|---|
| | OR (95% CI) | *p* | OR (95% CI) | *p* | OR (95% CI) | *p* | OR (95% CI) | *p* | OR (95% CI) | *p* |
| **PI** | 0.98 (0.95;1.01) | 0.20 | 0.98 (0.95;1.01) | 0.13 | 1.00 (0.97;1.03) | 0.20 | 0.98 (0.93;1.03) | 0.39 | 0.98 (0.94;1.02) | 0.33 |
| **PT** | 0.97 (0.91;1.03) | 0.31 | 0.98 (0.93;1.03) | 0.48 | 0.99 (0.94;1.04) | 0.75 | 0.96 (0.87;1.06) | 0.42 | 0.97 (0.89;1.06) | 0.49 |
| **SS** | 0.98 (0.94;1.02) | 0.33 | 0.97 (0.94;1.01) | 0.13 | 1.00 (0.97;1.04) | 0.85 | 0.98 (0.92;1.05) | 0.55 | 0.98 (0.92;1.03) | 0.42 |
| **LL** | 1.01 (0.97;1.05) | 0.62 | 1.00 (0.96;1.03) | 0.79 | 1.02 (0.99;1.05) | 0.31 | 1.00 (0.94;1.07) | 0.93 | 1.01 (0.96;1.06) | 0.67 |

| | Lateral center edge angle - mean | | Left | | Right | | Women | | Men | |
|---|---|---|---|---|---|---|---|---|---|---|
| | β (95% CI) | *p* | β (95% CI) | *p* | β (95% CI) | *p* | β (95% CI) | *p* | β (95% CI) | *p* |
| **PI** | 0.004 (-0.047;0.054) | 0.89 | 0.000 (-0.052;0.053) | 0.99 | 0.007 (-0.049;0.063) | 0.81 | 0.014 (-0.061;0.089) | 0.71 | -0.013 (-0.085;0.059) | 0.72 |
| **PT** | 0.050 (-0.048;0.148) | 0.32 | 0.015 (-0.086;0.116) | 0.77 | 0.085 (-0.023;0.192) | 0.12 | 0.087 (-0.058;0.232) | 0.24 | -0.025 (-0.168;0.118) | 0.73 |
| **SS** | -0.017 (-0.083;0.05) | 0.62 | -0.006 (-0.075;0.062) | 0.85 | -0.027 (-0.100;0.046) | 0.47 | -0.016 (-0.115;0.084) | 0.76 | -0.011 (-0.102;0.08) | 0.81 |
| **LL** | 0.013 (-0.048;0.074) | 0.67 | 0.029 (-0.034;0.091) | 0.37 | -0.002 (-0.069;0.064) | 0.94 | 0.007 (-0.086;0.099) | 0.89 | 0.019 (-0.062;0.101) | 0.64 |

β-coefficients were calculated using linear regression models and odds ratios (OR) were calculated using logistic regression models adjusted for age, sex, body-mass index, hypertension, total cholesterol, HDL-C, triglycerides, diabetes status, and physical activity.

**Table 4.** Multivariable correlation of HOA MRI Score and LCE with back pain

| Risk factors | Back pain* | | Back pain**# | |
|---|---|---|---|---|
| | OR (95% CI) | p | OR (95% CI) | p |
| **HOA overall** | 1.05 (0.52;2.14) | 0.88 | 0.86 (0.44;1.69) | 0.66 |
| **left** | 0.95 (0.52;1.73) | 0.86 | 0.83 (0.47;1.45) | 0.51 |
| **right** | 1.28 (0.73;2.27) | 0.39 | 0.92 (0.53;1.59) | 0.76 |
| **LCE mean** | 1.00 (0.96;1.04) | 0.95 | 0.99 (0.96;1.03) | 0.71 |
| **left** | 0.98 (0.94;1.02) | 0.26 | 0.98 (0.94;1.02) | 0.26 |
| **right** | 1.02 (0.98;1.06) | 0.36 | 1.01 (0.97;1.04) | 0.71 |

Odds ratios are calculated using (#ordered) logistic regression models adjusted for age, sex, body-mass index, hypertension, total cholesterol, HDL-C, triglycerides, diabetes status, physical activity *(yes/no), ** (Not at all, little, medium, strong, very strong).

# Figure Legends

**Fig. 1 -** Overview of spinopelvic parameters illustrated using T1 vibe Dixon in-phase images: (a) pelvic incidence, (b) pelvic tilt, and (c) sacral slope. Bent double arrows: measured angle; cFH: center of femoral head; FH: femoral head; L 4: Lumbar vertebra 4.

**Fig. 2 -** Measurement technique of lateral center edge angle (LCE) for the left and right hip joint on a mid-coronal T1 vibe dixon in phase. Bent double arrows: measured angle.

**Fig. 3 -** Image examples of the degenerative stages of the OA MRI score (T1 vibe dixon in phase). **A:** Grade 0 – no degeneration; **B:** Grade 1 - small osteophytes (grey arrow) and borderline narrowing of the cranial joint gap (white arrow); **C:** Grade 2 – small osteophytes (grey arrows), heavy narrowing of the joint space (white arrows) and little subchondral lesions (black arrow); **D:** Grade 3 - small osteophytes (grey arrows), loss of joint gap medially (white arrow) and heavy pseudocystic lesions (black arrow). Grade 4 is not depicted due to not being awarded to any case in the cohort.

**Fig. 4 -** Flow chart illustrating subject selection and exclusion.

**Fig. 5 - a** Pelvic tilt value in patients with (dark gray) and without (light gray) HOA, **b** Pelvic incidence value in patients with and without HOA, **c** sacral slope value in patients with and without HOA and **d** lumbar lordosis in patients with and without HOA.

Figure 1 

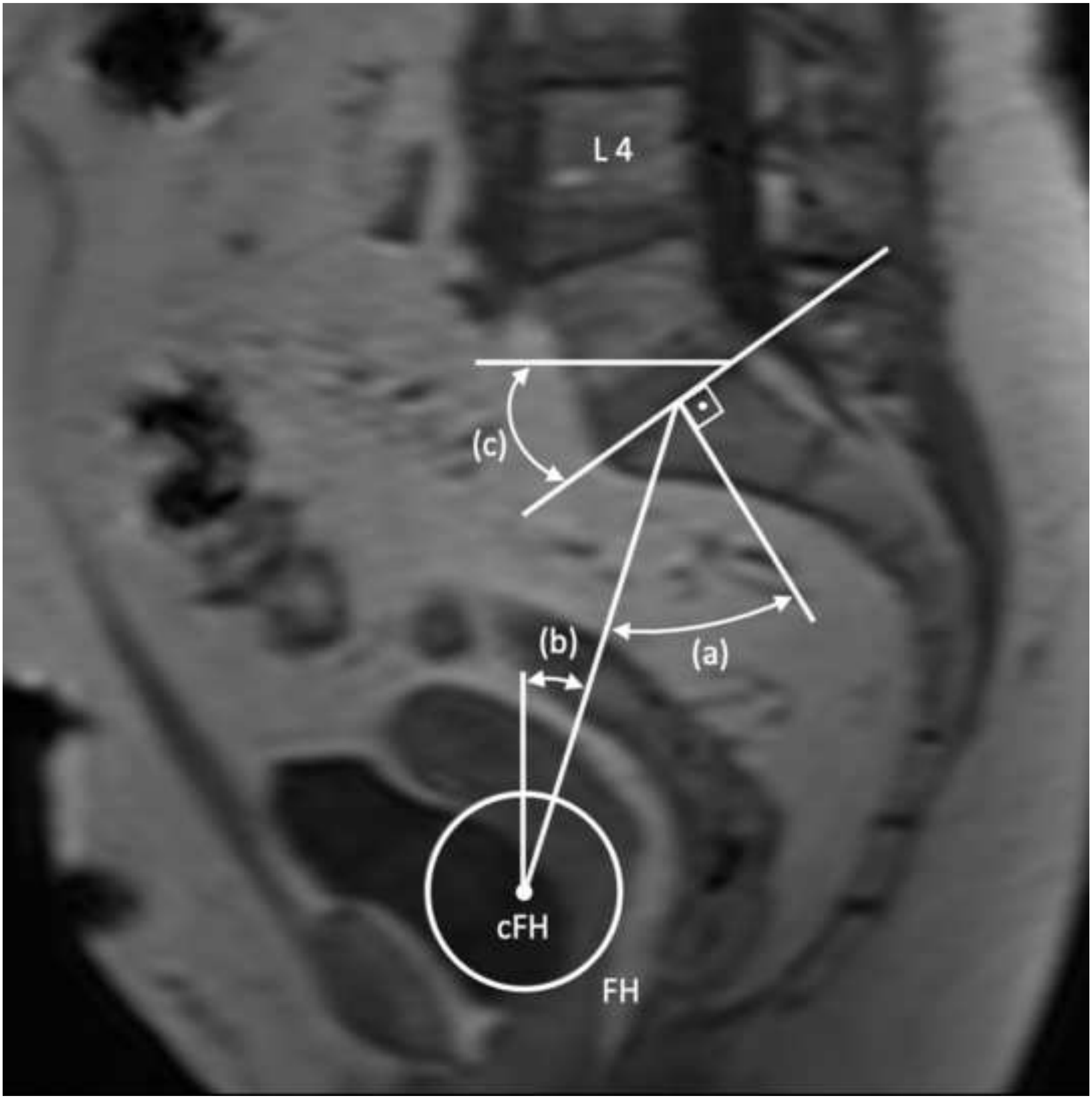


Figure 2



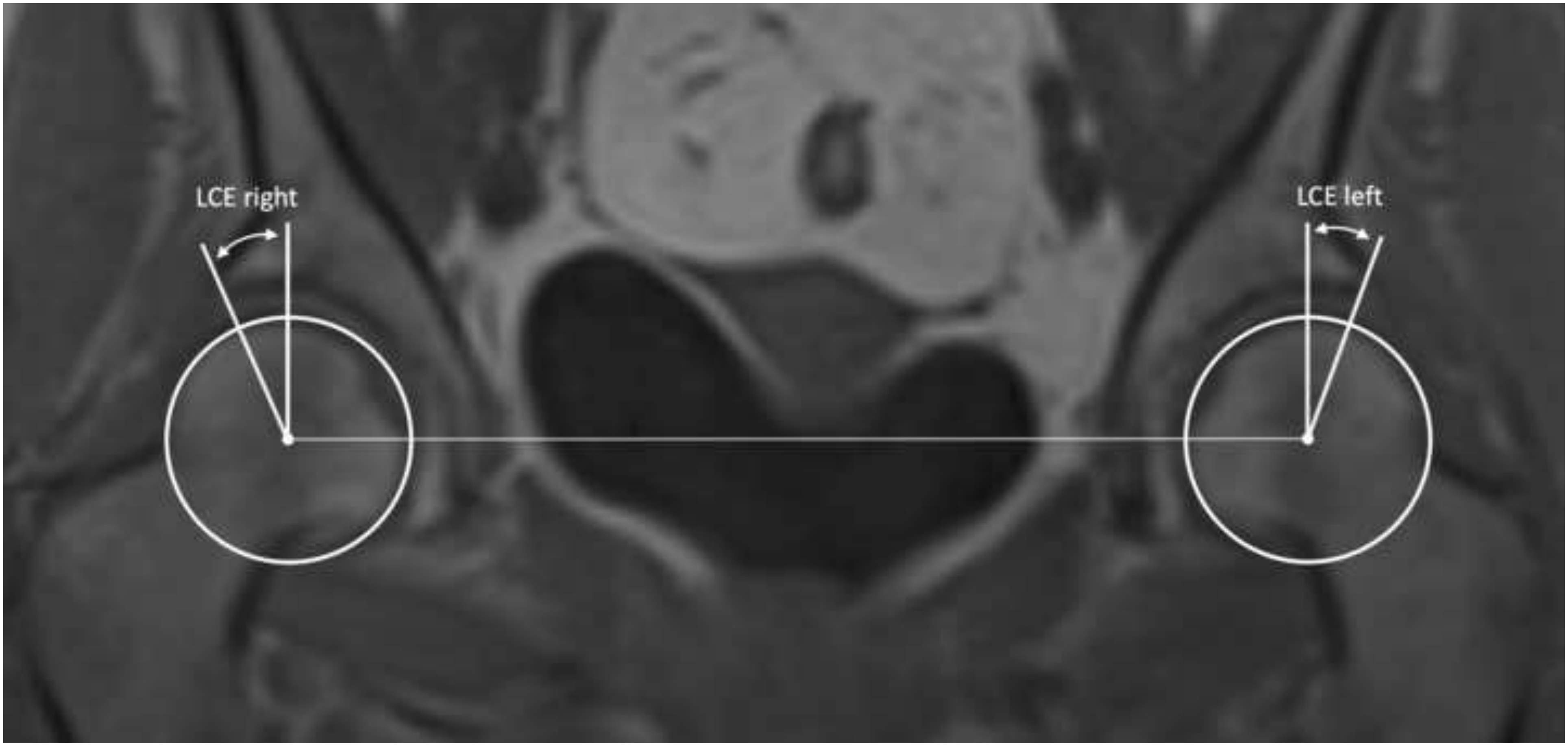


Figure 3a

Click here to access/download;Figure;Fig3a.tiff

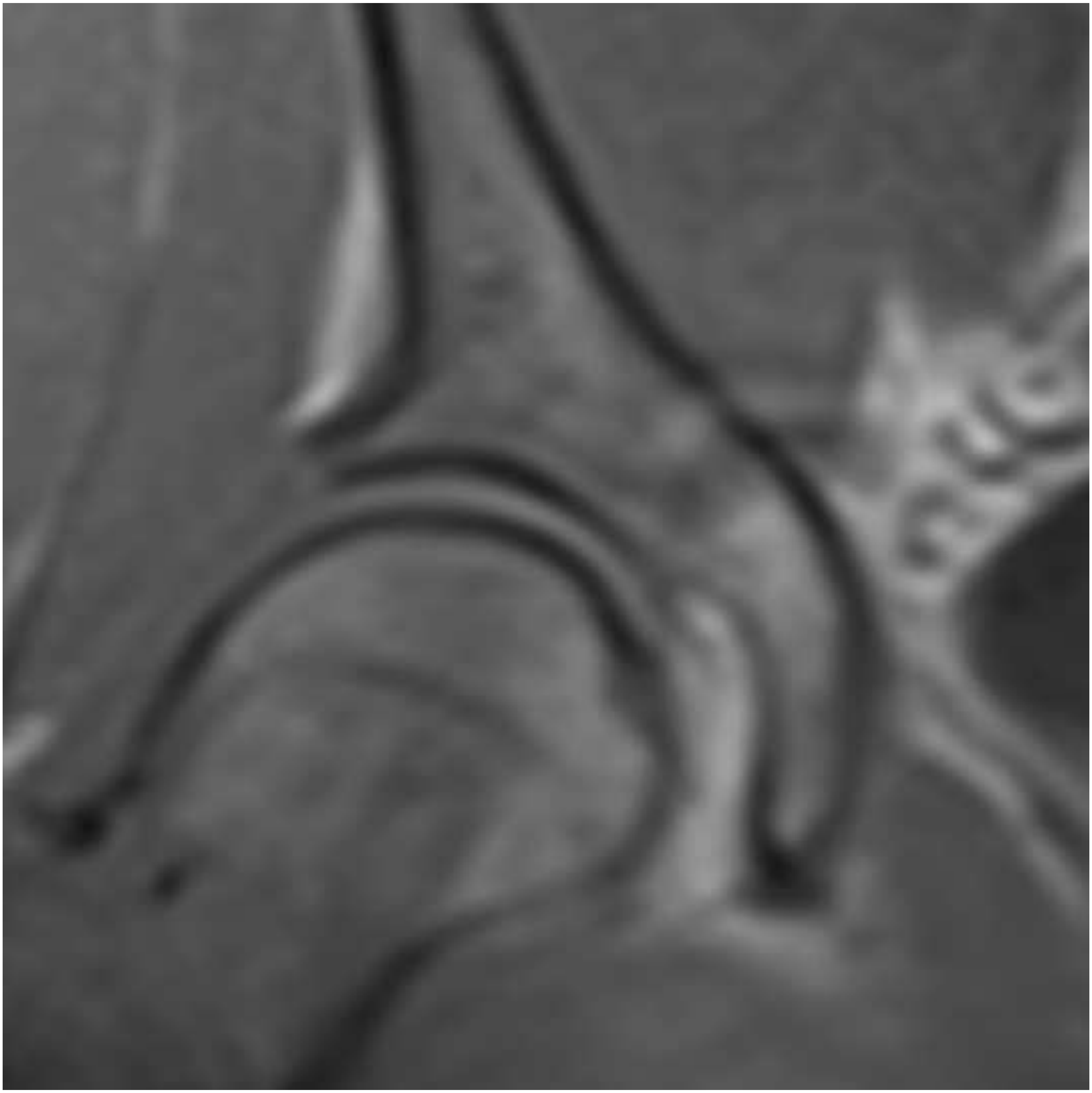


Figure 3b



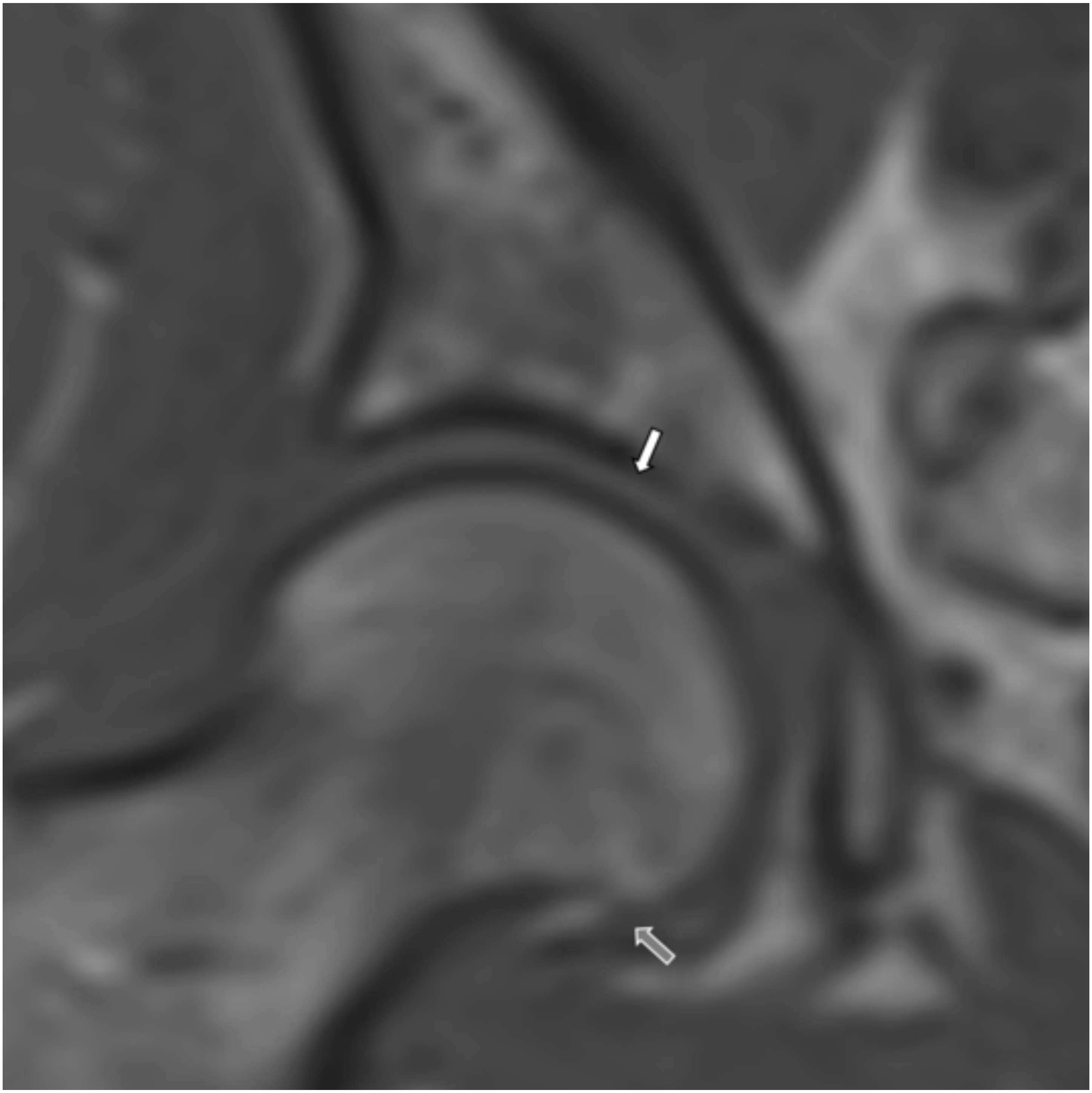


Figure 3c



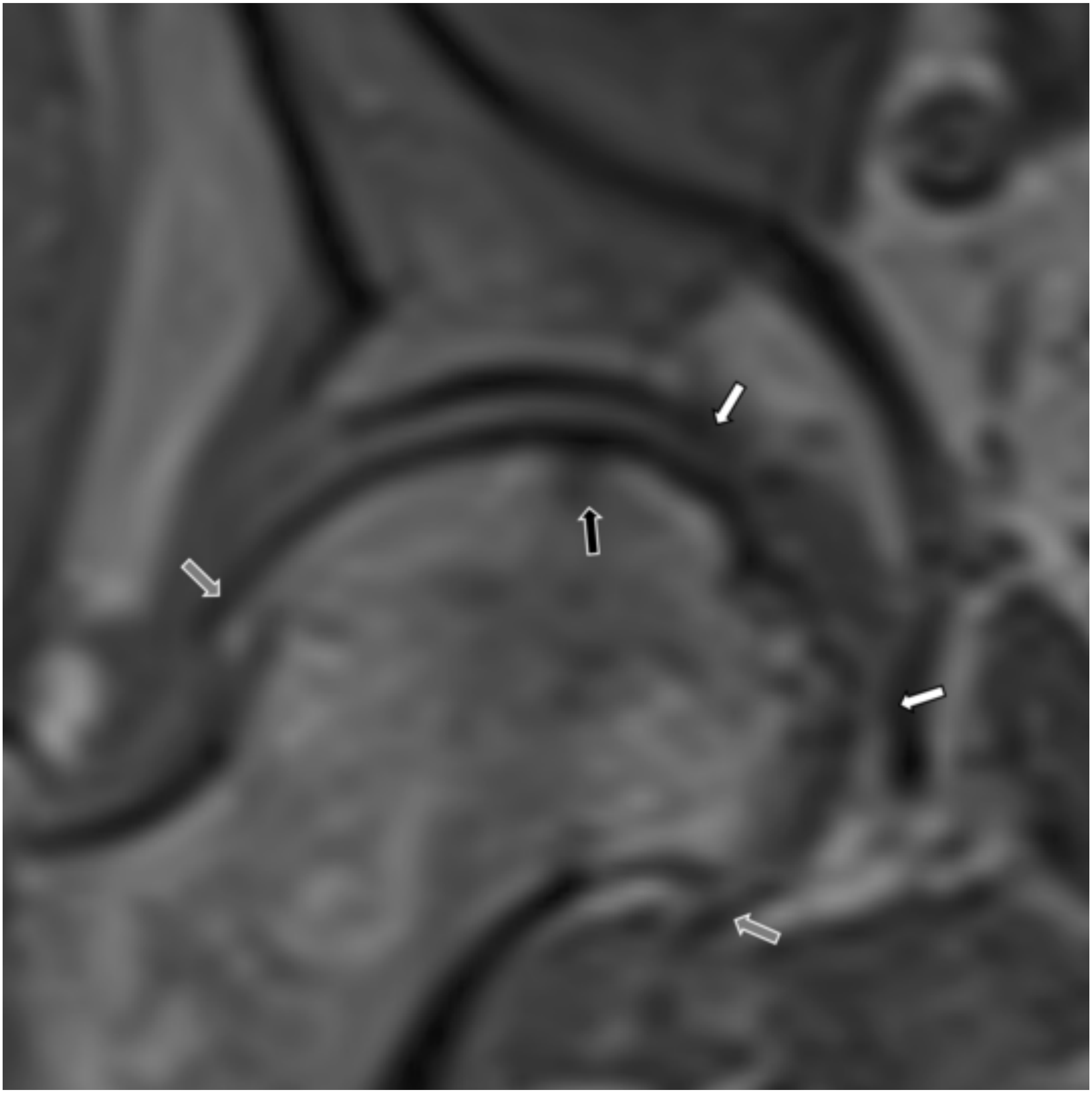


Figure 3d



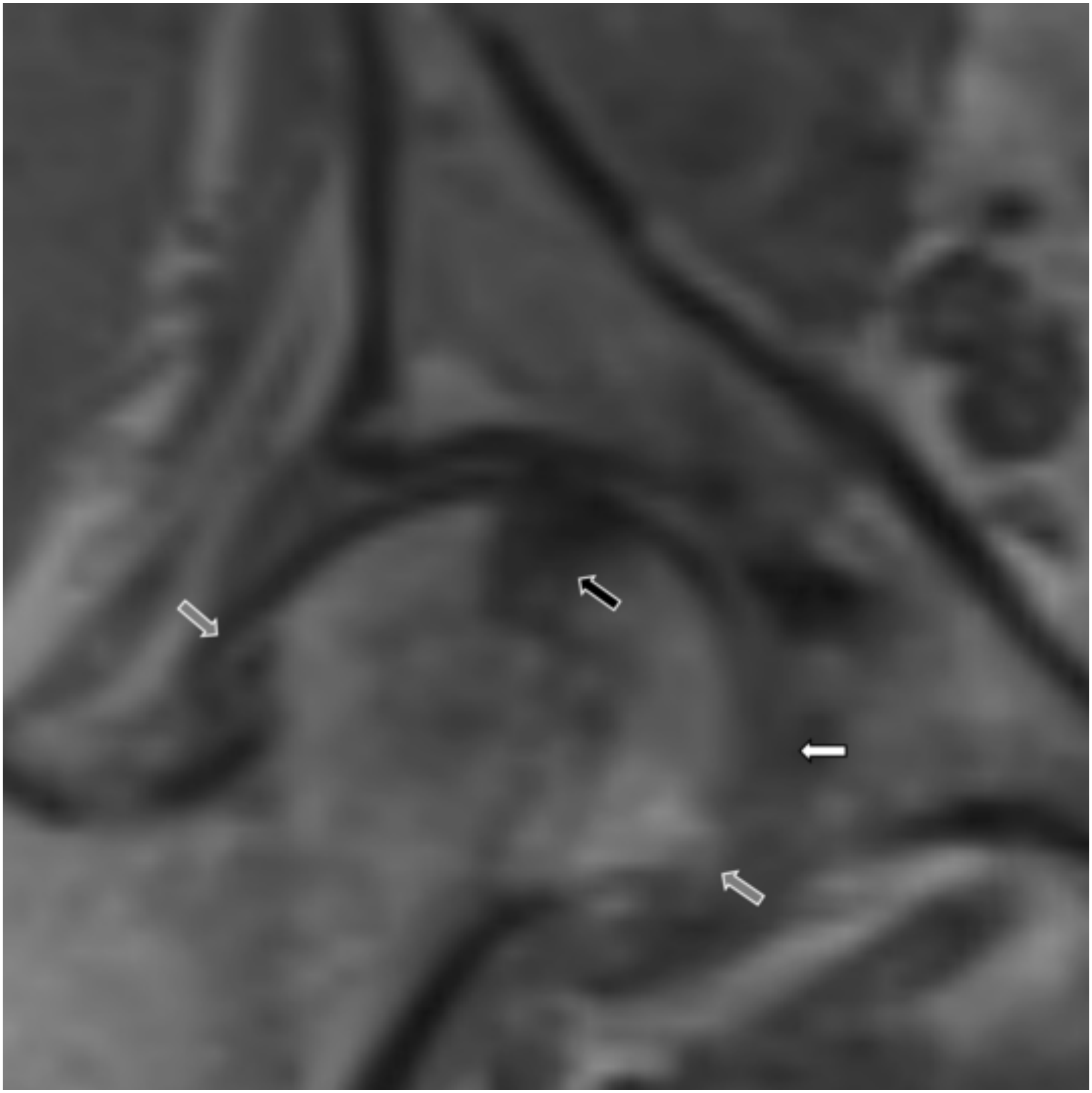


Figure 4 

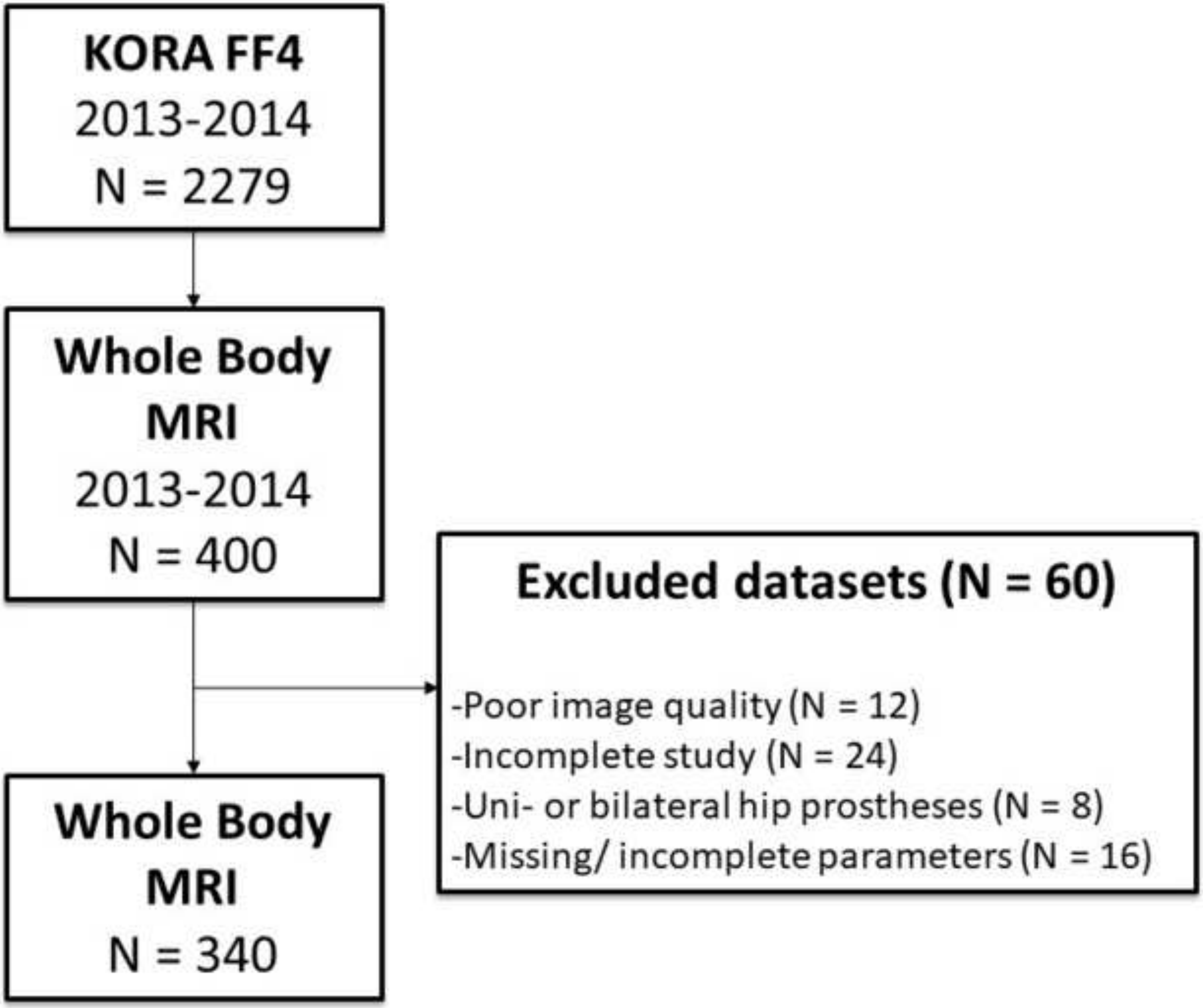
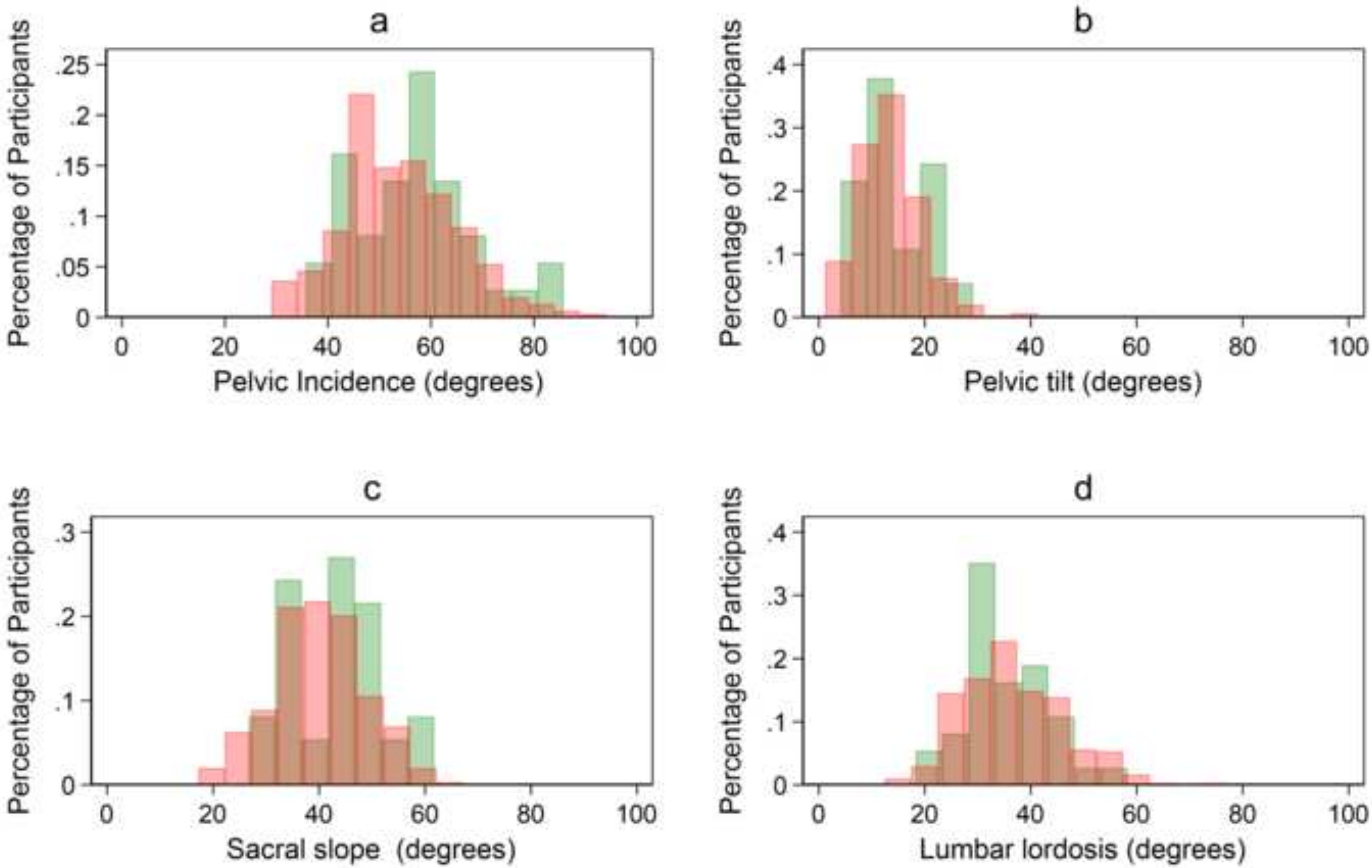

KORA FF4
2013-2014
N = 2279
Whole Body
MRI
2013-2014
N = 400
Excluded datasets (N = 60)
-Poor image quality (N = 12)
-Incomplete study (N = 24)
-Uni- or bilateral hip prostheses (N = 8)
-Missing/ incomplete parameters (N = 16)
Whole Body
MRI
N = 340

Figure 5





a
Percentage of Participants
.25
.2
.15
.1
.05
0
0
20
40
60
80
100
Pelvic Incidence (degrees)
b
Percentage of Participants
.4
.3
.2
.1
0
0
20
40
60
80
100
Pelvic tilt (degrees)
c
Percentage of Participants
.3
.2
.1
0
0
20
40
60
80
100
Sacral slope (degrees)
d
Percentage of Participants
.4
.3
.2
.1
0
0
20
40
60
80
100
Lumbar lordosis (degrees)

# Credit Author Statement

Elke Maurer: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing original draft, Visualization

Roberto Lorbeer: Methodology, Validation, Formal analysis, Writing – review and editing, Supervision

Gerald Hefferman: Methodology, Validation, Formal analysis, Writing – review and editing

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# Highlights

- No correlation between spinopelvic parameters and hip osteoarthritis in supine MRI
- Furthers knowledge about impact of spinopelvic parameters on musculoskeletal system
- Helps to clarify the potential etiologies of hip osteoarthritis

## CERTIFICATE OF ENGLISH EDITING

To whom it may concern,

This certifies that the submitted paper with the title “**Lack of Correlation between Hip Osteoarthritis and Anatomical Spinopelvic Parameters Obtained in Supine Position on MRI**”, by Dr. Elke Maurer and Dr. Sven S. Walter has been proofread and edited for the English language by myself.

Sincerely,

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