RESEARCH ARTICLE

Are Standing Spinopelvic Parameters Different in Patients with Hip Osteoarthritis Compared to Healthy Individuals? A Comparative Study

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Received: 21 October 2024 *Accepted: 22 February 2025*

Abstract

Objectives: This case-control study aimed to investigate standing sagittal spinopelvic alignment in patients with advanced hip osteoarthritis (HOA) and to determine whether their alignment differs from that of healthy individuals.

Methods: This study included 240 participants, comprising 120 healthy individuals in the control group and 120 candidates for total hip arthroplasty due to primary HOA in the case group. Pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT) were measured in both groups using standing lateral X-rays.

Results: The demographic characteristics of the two groups were not significantly different. In patients with primary HOA, the mean PI, PT, and SS angles were 52.3 ± 10.1, 9.2 ± 4.2, and 44.4 ± 9.3 degrees, respectively. In the control group, the mean PI, PT, and SS values in were 50.2 ± 8.1, 11.2 ± 5.5, and 39.1 ± 8.5 degrees, respectively. The P-value indicated no significant difference in spinopelvic parameters between the control and case groups.

Conclusion: Our study demonstrated that standing spinopelvic parameters do not significantly differ between patients with primary HOA and healthy individuals.

Level of evidence: III

Keywords: Hip, Osteoarthritis, Spine, Spinopelvic, Total hip arthroplasty

Introduction

Hip osteoarthritis (HOA), a degenerative joint disease marked by the breakdown of cartilage, is a leading cause of pain and limitations in daily activities, with a global prevalence of 8.55%.[1] While aging is the most significant risk factor, various other factors, including obesity, gender, ethnicity, and genetics, also contribute to its development.[2] Additionally, previous studies have suggested that the relationship between the hip and spine may lead to disorders affecting both regions.[3] The connection between the sagittal alignment of the spinopelvic junction and spinal pathologies has been well-studied.[4-7] However, the role of sagittal spinopelvic parameters, including pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) in primary HOA, remains less studied.

Previous studies on the relevance of PI and HOA have yielded inconsistent results, suggesting either that a significant relationship does not exist or that a higher PI may predispose individuals to osteoarthritis (OA).[8,9] Gebhart *et al.*[10] reported a significant correlation between high PI and HOA in their study of cadaveric specimens, while Raphael *et al.*[11] reported no such connection. The evidence has been debatable, and even fewer studies have been conducted to explore the significance of PI in other hip pathologies.

Due to the aforementioned controversies and a lack of sufficient knowledge, the present study aims to compare the spinopelvic parameters between patients with HOA and healthy subjects without hip pathology.

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Materials and Methods

Our institutional ethical board review approved this study. One hundred twenty patients with advanced primary HOA who were candidates for total hip arthroplasty were included in the case group. The exclusion criteria for the HOA group were as follows: (1) secondary arthritis due to other conditions affecting in the hip, such as developmental dysplasia of the hip, ankylosing spondylitis, rheumatoid arthritis, avascular necrosis, infection, or tumors; (2) previous hip surgeries; and (3) any condition that could alter the sagittal alignment of the spine and pelvis, includng spinal deformities, spondylolisthesis, and a history of fractures. Additionally, 120 asymptomatic volunteers without any hip or spine pathology were enrolled in the control group. The inclusion criteria for the control group were: (1) age between 40 and70 years; (2) no spinal pathology or deformity; and (3) no history of hip, pelvic, or lower limb disorders.

Two orthopedic surgeons independently measured the following parameters on standing lateral X-rays to assess sagittal spinopelvic alignment. By averaging the values obtained from both examiners, the following spinal parameters were calculated: pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS). The PI is defined as the angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this midpoint to the center of the femoral head [Figure 1 a].[12] The PT measures the angle between a vertical line drawn from the center of the femoral head and a line connecting this center to the midpoint of the sacral plate [Figure 1 b].[13] The SS is the angle between the sacral end-plate and a horizontal line, as shown in [Figure 1 c].

We used SPSS (version 27.0) for Windows to analyze the data. All pelvic parameters were measured using the Medicaid 3.5 demo by two orthopedic surgeons involved in the study. Continuous data were compared using the Student's t-test, and categorical data were analyzed using either the chi-squared or Fisher's exact test. The threshold for statistical significance was established at P < 0.05.

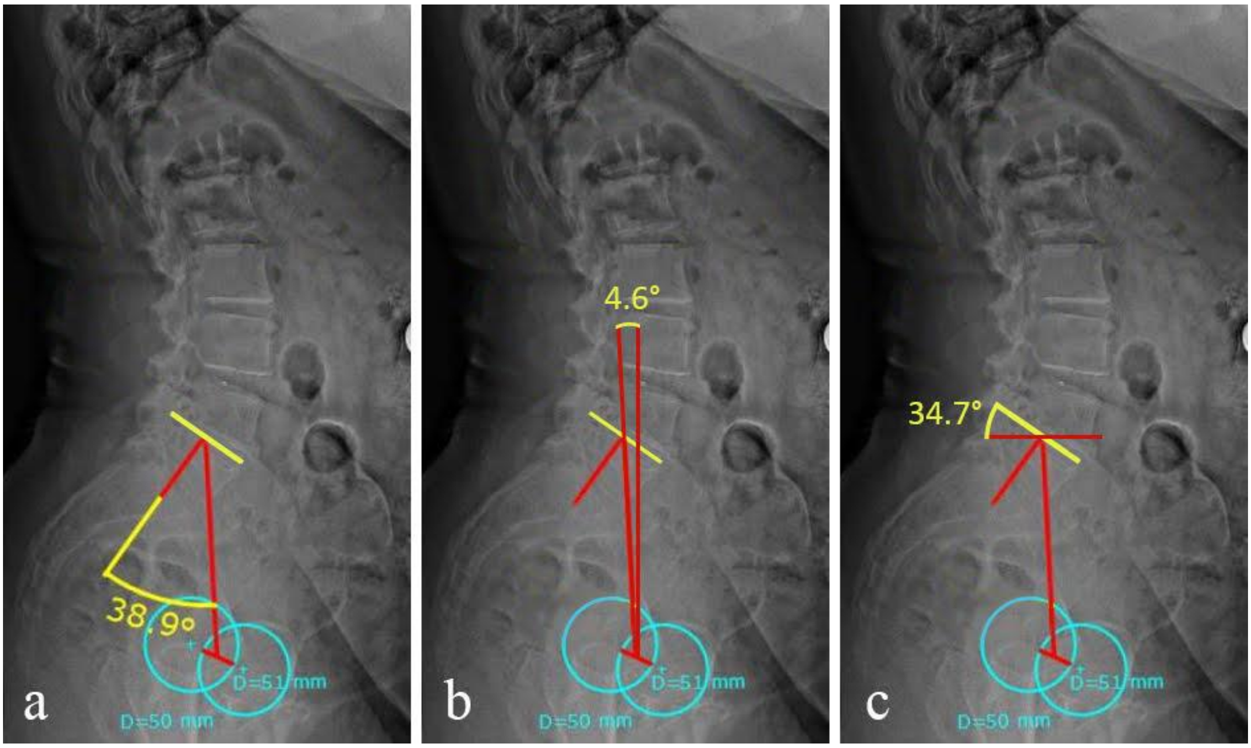

Figure 1. Measurement of standing spinopelvic parameters. a: pelvic incidence. b: pelvic tilt. c: sacral slope

Results

The demographic characteristics of the participants and the spinopelvic parameters for each group are summarized in [Table 1]. The study included 38 males and 82 females with HOA, with a mean age of 60.2 years (±7.6). In the control group, there were 44 males and 76 females, with a mean age of 58.9 years (±9). No significant differences were noted in age and gender distribution between the two groups (*P*-values: 0.09 and 0.12, respectively).

Patients in the HOA group and the control group showed comparable values regarding PI (52.3 ± 10.1 vs. 50.2 ± 8.1, P-value: 0.770), PT (9.2 ± 4.2 vs. 11.2 ± 5.5, P-value: 0.310), and SS (44.4 ± 9.3 vs. 39.1 ± 8.5, P-value: 0.450). The Student's t-test showed no significant differences in spinopelvic parameters between the HOA group and healthy subjects.

Table 1. Demographic data and summary of findings.

	HOA (n = 120)	Healthy controls (n = 120)	*P*-value
Age, year	60.2 ± 7.6 (50-90)	58.9 ± 9.0 (40-68)	0.09
Sex, female: male	82 (68.3): 38 (31.7)	76 (63.3): 44 (36.7)	0.12
PI, degree	52.3 + 10.1 (27.7-78.1)	50.2 + 8.1(27.9-84.5)	0.77
PT, degree	9.2 + 4.2 (1.8-24.8)	11.2 + 5.5 (2.0-25.3)	0.31
SS, degree	44.4+9.3 (22.0-57.2)	39.1 + 8.5 (19.0-60.0)	0.45

Data are shown as mean + SD (range) or N (%). HOA, hip osteoarthritis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope.

Intraexaminer agreement rates for the HOA and control groups were excellent for both examiners 1 and 2 across all spinopelvic parameters. Additionally, interexaminer agreement rates were also excellent for the HOA and control groups during the first and second measurements of all spinopelvic parameters. Furthermore, the interexaminer agreement rates for the mean values between the first and second measurements for both the HOA and control groups were also excellent [Table 2].

We also performed a post hoc power analysis. The power of our study to detect significant differences in PI, PT, and SS between the HOA and control groups was 42.4%, 88.3%, and 99.5%, respectively.

Table 2. Intraexaminer and interexaminer variability for spinopelvic measurements.

	HOA ICC (95% CI)	Healthy controls ICC (95% CI)
PI		
Intraexaminer variability		
Examiner 1:		
First measurement vs second measurement	0.991 (0.985, 0.995)	0.976 (0.963, 0.984)
Examiner 2:		
First measurement vs second measurement	0.983 (0.970, 0.990)	0.963 (0.936, 0.979)
Interexaminer variability between examiner 1 and 2		
First measurement	0.978 (0.961, 0.988)	0.969 (0.942, 0.983)
Second measurement	0.977 (0.959, 0.987)	0.973 (0.953, 0.985)
Mean value between the first and second measurement	0.946 (0.905, 0.969)	0.926 (0.867, 0.958)
PT		
Intraexaminer variability		
Examiner 1:		
First measurement vs second measurement	0.990 (0.985, 0.995)	0.936 (.0.930, 0.941)
Examiner 2:		
first measurement vs second measurement	0.920 (0.901, 940)	0.937 (0.917, 0.957)
Interexaminer variability between examiner 1 and 2		
First measurement	0.945 (0.906, 0.984)	0.980 (0.960, 1.00)
Second measurement	0.970 (0.950, 0.990)	0.910 (0.890, 0.930)
Mean value between the first and second measurement	0.906 (0.886, 0.926)	0.915 (0.895, 0.935)
SS		
Intraexaminer variability		
Examiner 1:		
First measurement vs second measurement	0.956 (0.935, 0.974)	0.966 (0.946, 0.985)
Examiner 2:		
First measurement vs second measurement	0.928 (0.909, 0.948)	0.919 (0.880, 0.958)
Interexaminer variability between examiner 1 and 2		
First measurement	0.943 (0.904, 0.982)	0.978 (0.958, 0.998)
Second measurement	0.961 (0.940, 0.981)	0.913 (0.847, 0.952)
Mean value between the first and second measurement	0.925 (0.886, 0.964)	0.978 (0.958, 0.998)

CI, confidence interval; HOA, hip osteoarthritis; ICC, intraclass correlation coefficient; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope.

Discussion

This study investigated the sagittal spinopelvic alignment of 120 patients with advanced HOA compared to 120 age- and gender-matched asymptomatic individuals. Our findings indicate that standing spinopelvic parameters do not differ between patients with OA and healthy subjects. These findings suggest that there is no association between changes in these indices and the presence of HOA.

The relationship between HOA and spinopelvic parameters, such as PI has been extensively studied; however, it remains a topic of debate. The PI is an anatomical parameter that remains constant for an individual after growth ceases and is not affected by the position of the pelvis.[14,15] The role of PI in the development and progression of several spinal disorders, including spondylolisthesis and idiopathic scoliosis, has been well documented.[16-20] Previous studies have yielded inconsistent results regarding the effect of PI on HOA [Table 3]. Two studies support the hypothesis that a higher PI contributes to the development of primary HOA. Yoshimoto *et al.*[21] compared spinopelvic alignments between patients with HOA and those with low back pain who underwent spinal surgical procedures. In contrast to our findings, they concluded that PI was significantly greater in patients with HOA, showing a strong correlation with PT, SS, and lumbar lordosis (LL), suggesting that a larger PI is a possible risk factor for HOA development. Additionally, a cadaveric study involving 400 samples conducted by Gebhart *et al.*[10] investigated the relationship between different grades of HOA and PI, revealing a significant correlation between PI and HOA grading.

Table 3. Summary of previously published studies.

Author	Case group (n)	Control group (n)	Mean PI (case vs. control)	Mean PT (case vs. control)	Mean SS (case vs. control)
Yoshimoto et al. (2005)	HOA (150)	Low back pain (150)	58.5 vs 51.9*	17.0 vs 20.7*	41.4 vs 31.2*
Sariali et al. (2009)	HOA (89)	Healthy individuals (100)	51.7 vs 52.7	Not measured	20.6 vs 39.4*
Weng et al. (2015)	HOA (58)	Healthy individuals (64)	49 vs 46	9.7 vs 12.9*	39.4 vs 32.8*
Raphael et al. (2016)	Radiologic HOA (95)	Absent HOA in CT (87)	56.5 vs. 57.2	Not measured	Not measured
Gebhart et al. (2016) (cadaveric)	Hip arthritis present in cadavers	Hip arthritis absent in cadavers	46.7 (cases and controls)	Not measured	Not measured
Bendaya et al. (2015)	Radiologic HOA (30)	Absent HOA in x-ray (30)	56.3 vs 52.1	14.3 vs 14.7	42.3 vs 37.6*

* Indicates statistically significant. HOA, hip osteoarthritis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope.

Different study designs may account for the inconsistency with our findings. Yoshimoto *et al.*[21] included patients with mild dysplastic hips (Crow type 1). In their study, the control group also comprised patients with lumbar spine disorders requiring surgical intervention, whereas we included only healthy participants. The etiology of HOA in the study by Gebhart *et al.*[10] remains undetermined due to its cadaveric nature. Although they excluded patients with obvious periarticular trauma, obvious metabolic or rheumatologic diseases, and evidence of infection affecting the joint surface, the specific etiology of HOA was not indicated in their study.

Regarding PI, four additional studies have reported results consistent with ours. Raphael *et al.*[10] compared PI values calculated from pelvic CT scans in patients with and without radiologic signs of HOA and found no significant difference in PI. Similarly, Sariali *et al.*[22], Weng *et al.*[23], and Bendaya *et al.*[24] reported no differences in PI values between patients with HOA and healthy volunteers. Our results support these studies, indicating that PI values do not differ between patients with HOA and healthy individuals. In a recent study by Soydan *et al.*[25], which assessed the impact of spinopelvic alignment on HOA, the same conclusion was reached as in our study. We attribute the consistency of our findings with those of the above-mentioned studies to the inclusion of healthy participants as the control group, similar to their methodology. Additionally, in a review article published by Saltychev *et al.*[9], the authors investigated the role of PI in hip disorders and concluded that the evidence regarding the relationship between PI and HOA remains inconclusive.

The role of PT and SS values in primary HOA is even more debatable in the literature. Weng *et al.*[23] showed a decrease in PT among patients with primary HOA, hypothizing that hip flexion contracture, which is common in HOA, leads to an anteverted pelvis to maintain the position of the femoral head on the pelvis. If pelvic anteversion and increased LL fail to compensate for hip flexion contracture, global sagittal imbalance is more prevalent in the OA group. In contrast, Watanabe *et al.*[26] and Mekhael *et al.*[27] stated that an increase in PT, associated with decreased LL, leads to reduced anterior acetabular coverage of the femoral head. This decreased contact area results in increased stress on the hip joint, potentially contributing to the progression of HOA. Yoshimoto *et al.*[21] and Sariali *et al.*[22] also showed increased PT inpatients with HOA. However, consistent with our findings in a recent study, Soydan *et al.*[25] showed no association between PI-LL imbalanceand the development of HOA. Consequently, there is no consensus regarding the impact of spinopelvic parameters on HOA development. In the present study, PT and SS were similar between patients with HOA and healthy subjects. Our results may be explained by the opposite direction of PT and hip flexion contracture. We might assume that increased PT leads to HOA, while hip flexion contracture affects sagittal alignment by decreasing PT and increasing SS to maintain normal sagittal balance. Due to the absence of comprehensive radiographs of the whole spine, pelvis, and proximal femur, we were unable to measure sagittal alignment parameters such as LL, thoracic kyphosis, and C7 spinopelvic inclination. In addition, the pelvic femoral angle, which indicates the prescence of hip flexion contracture, was not measured in this study. Future studies should address these limitations.

There are several significant limitations to our study. One limitation is that the power analysis for detecting a significant difference in PI values between the groups was below the acceptable threshold of 80% (actual power = 42.4%), which impacts the reliability of our interpretations. Another limitation is the retrospective nature of the analysis. Due to the abscence of proper X-ray imaging from C1 to proximal femurs, we were unable to measure key parameters of sagittal alignment of the spine and femurs, such as T1 spinal-pelvic inclination (SPI), pelvic femoral angle (PFA) in the present study. Weng *et al.*[23] showed that important findings, such as retroverted femurs or unbalanced spinal sagittal alignment, may be present in patients with HOA. Another limitation of the study is that it included only patients with advanced HOA who were candidates for arthroplasty. Consequently, the findings may not be generalizable to patients in earlier stages of the disease. This selective inclusion may introduce bias, as the observed spinopelvic alignment in these patients could reflect adaptations to advanced disease rather than the underlying mechanisms contributing to the onset of HOA. Therefore, the influence of long-standing HOA on spinopelvic alignment may be confounded by the potential effects of pre-existing spinopelvic alignment abnormalities on the development of HOA. Future research that incorporates patients across all stages of HOA is warranted to clarify these complex interactions. Additionally, we did not consider several potential confounders, such as body mass index (BMI), alcohol consumption, history of trauma, and genetic predisposition. These omissions could have significantly influenced the findings of the study. For instance, BMI has been shown to affect both spinopelvic alignment and joint, with higher BMI associated with increased joint stress and alterations in PI and LL, which could modify the relationship between the PI and HOA.[28,29] These limitations may obscure the underlying mechanisms linking spinopelvic parameters to the development of HOA. Future research should address these factors to facilitate a more accurate interpretation of the relationship between spinopelvic parameters and HOA.

Conclusion

Our study showed no statistically significant differences in standing sagittal spinopelvic indices, including PI, SS, and PT, between healthy individuals and patients with advanced HOA. Additionally, we found no association between changes in these indices and the presence of HOA. However, further research utilizing a prospective design and larger sample sizes is required.

Acknowledgement

The authors thank the staff of Imam Khomeini Hospital for their cooperation.

Authors Contribution: Authors who conceived and designed the analysis: Seyed Mohammad Javad Mortazavi, Mohammad Reza Barzegar/Authors who collected the data: Furqan Mohammed Yaseen Khan/ Authors who contributed data or analysis tools: Hooshmand Zarei, Seyed Mohammadmisagh Moteshakereh/ Authors who performed the analysis: Furqan Mohammed Yaseen Khan, Hooshmand Zarei/ Authors who wrote the paper: Mohammadreza Razzaghof, Mohammad Ghorbanzadeh, Mohammad Reza Barzegar

Declaration of Conflict of Interest: The authors do not have any potential conflicts of interest for this manuscript.

Declaration of Funding: The authors received no financial support for the preparation, research, authorship, and publication of this manuscript.

Declaration of Ethical Approval for Study: This study was conducted under the ethics approval code IR.TUMS.MEDICINE.REC.1400.1442, granted by the Ethics Committee of Tehran University of Medical Sciences.

Declaration of Informed Consent: Written informed consent was obtained from all participants.

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