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Original Research Article

SPINOPELVIC MOBILITY AND ITS IMPACT ON FUNCTIONAL OUTCOMES FOLLOWING TOTAL HIP ARTHROPLASTY

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ABSTRACT

Background: Spinopelvic mobility plays a critical role in determining functional acetabular orientation during postural changes and has important implications for biomechanics following total hip arthroplasty (THA). Abnormal spinopelvic motion may influence early functional recovery and postoperative stability; however, prospective data evaluating its impact on functional outcomes remain limited. **Objective:** To evaluate the effect of preoperative spinopelvic mobility on early functional outcomes following primary total hip arthroplasty.

Materials and Methods: This prospective single-center observational study included 50 consecutive patients undergoing primary total hip arthroplasty between March 2025 and August 2025. Preoperative spinopelvic mobility was assessed using standing and seated lateral radiographs, with mobility quantified by the change in sacral slope (ΔSS). Patients were classified as stiff (ΔSS < 10°), normal (ΔSS 10°–30°), or hypermobile (ΔSS > 30°). Functional outcomes were assessed using the Harris Hip Score (HHS) and visual analog scale (VAS) for pain preoperatively and at 4 months postoperatively. The primary outcome was improvement in HHS at 4 months. Secondary outcomes included postoperative instability and complications.

Results: Among the 50 patients, 28 (56%) demonstrated normal spinopelvic mobility, 12 (24%) had stiff mobility, and 10 (20%) were hypermobile. Mean HHS improved from 45.6 ± 7.8 preoperatively to 85.1 ± 7.9 at 4 months. Patients with normal spinopelvic mobility showed significantly greater functional improvement compared with those with stiff or hypermobile mobility ($p = 0.004$). Stiff spinopelvic mobility was independently associated with reduced functional improvement after adjustment for demographic and clinical variables ($p = 0.007$). Hip dislocation occurred in 2 patients (4%), both in the abnormal mobility groups.

Conclusion: Preoperative spinopelvic mobility is significantly associated with early functional outcomes following total hip arthroplasty. Routine assessment of spinopelvic motion may help identify patients at risk for suboptimal early recovery and postoperative instability, thereby aiding surgical planning and patient counseling.

Keywords: Total hip arthroplasty; spinopelvic mobility; sacral slope; pelvic tilt; functional outcomes; prospective study.

INTRODUCTION

Total hip arthroplasty (THA) is a well-established and effective surgical procedure for the management of end-stage hip disorders, providing significant pain relief and improvement in functional capacity. Despite advances in implant design, surgical techniques, and perioperative care, variability in postoperative functional outcomes and complications such as instability continues to be reported.[1] This has led to increasing interest in patient-specific

biomechanical factors that may influence outcomes following THA.[2,3]

The functional orientation of the acetabular component is dynamic and changes with variations in pelvic position during activities of daily living.[4] Spinopelvic motion, particularly the interaction between the lumbar spine and pelvis during transitions from standing to sitting, plays a crucial role in determining functional acetabular inclination and anteversion.[5,6] Alterations in pelvic tilt during postural changes can significantly affect hip range of motion, impingement risk, and joint stability after THA.[7]

Abnormal spinopelvic mobility is commonly observed in patients with degenerative lumbar spine disease, reduced spinal flexibility, or sagittal imbalance.[8,9] Patients with stiff spinopelvic motion demonstrate limited posterior pelvic tilt while sitting, which may predispose them to anterior impingement and posterior instability.[10] Conversely, hypermobile spinopelvic patterns may result in excessive changes in functional acetabular orientation, potentially compromising stability during extension or flexion.[11] While these biomechanical relationships are increasingly recognized,[12] their clinical impact on early functional recovery following THA remains incompletely understood.

Most existing studies evaluating spinopelvic parameters in THA are retrospective in nature or focus primarily on radiographic outcomes and dislocation risk.[13] Prospective studies assessing the association between preoperative spinopelvic mobility and early patient-reported functional outcomes are limited, particularly within routine clinical practice settings.[14,15] Early postoperative functional recovery is an important determinant of patient satisfaction and return to daily activities, underscoring the need for further investigation.

The purpose of this prospective single-center study was to evaluate the impact of preoperative spinopelvic mobility on early functional outcomes following primary total hip arthroplasty, with functional assessment performed at 4 months postoperatively. We hypothesized that patients with abnormal spinopelvic mobility would demonstrate inferior early functional improvement compared with those with normal spinopelvic motion.

MATERIALS AND METHODS

Study design and setting

This was a **prospective single-center observational study** conducted at a tertiary care Orthopedic institution. Consecutive patients undergoing primary total hip arthroplasty (THA) were enrolled between **March 2025 and August 2025** and followed for a minimum of **4 months** postoperatively.

Ethical approval

The study protocol was approved by the Institutional Ethics Committee Written informed consent was obtained from all participants prior to inclusion. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Selection

This prospective single-center study included **consecutive patients undergoing primary total hip arthroplasty** between **March 2025 and August 2025**. All patients were screened for eligibility during the study period.

Inclusion Criteria

1. Patients aged **18 years or older**.
2. Patients undergoing **primary unilateral total hip arthroplasty**.
3. Indications for surgery including **primary osteoarthritis, avascular necrosis, inflammatory arthritis, or post-traumatic arthritis**.
4. Ability to **stand and sit independently** for standardized spinopelvic radiographic assessment.
5. Completion of **preoperative clinical evaluation**, including functional outcome scoring.
6. Willingness to provide **written informed consent** and comply with a **minimum 4-month postoperative follow-up**.

Exclusion Criteria

1. Patients undergoing **revision total hip arthroplasty**.
2. History of **lumbar spine fusion or spinal instrumentation**.
3. Presence of **neuromuscular disorders** affecting gait or posture.
4. **Severe spinal deformity or fixed sagittal imbalance** requiring surgical correction.
5. Inability to undergo **standardized standing and seated radiographic evaluation**.
6. Incomplete clinical data or **failure to complete the minimum 4-month follow-up**.

Preoperative Clinical Assessment

All patients underwent a standardized preoperative clinical evaluation. Demographic data including age, sex, and body mass index (BMI) were recorded. Clinical variables such as primary diagnosis, affected side, comorbidities, and history of spine-related symptoms were documented.

Baseline functional status was assessed using the **Harris Hip Score (HHS)**. Pain intensity was evaluated using the **visual analog scale (VAS)**. A focused clinical examination of the hip and spine was performed, including assessment of hip range of motion, limb length discrepancy, gait pattern, and presence of lumbar spine stiffness or pain.

All assessments were completed preoperatively and recorded by the treating orthopedic team prior to surgical intervention.

Radiographic Evaluation and Spinopelvic Assessment

Preoperative radiographic evaluation was performed using **standardized lateral radiographs of the pelvis and lumbar spine** obtained in two functional positions: **standing relaxed posture** and **seated position** with the hips and knees flexed to

approximately 90°. Radiographs were acquired following a standardized protocol to ensure reproducibility and minimize positional variability.

The following spinopelvic parameters were measured on the lateral radiographs: **sacral slope (SS)**, **pelvic tilt (PT)**, and **pelvic incidence (PI)**. Sacral slope was defined as the angle between the superior endplate of the sacrum and the horizontal plane, while pelvic tilt was defined as the angle between the vertical plane and the line joining the midpoint of the sacral endplate to the center of the femoral heads. Pelvic incidence was calculated as the sum of SS and PT.

Spinopelvic mobility was quantified using the **change in sacral slope (ΔSS)** between standing and seated positions, calculated as: ΔSS = SS_{standing} − SS_{seated}.

Based on ΔSS values, patients were classified into three groups: **stiff mobility (ΔSS < 10°)**, **normal mobility (ΔSS 10°–30°)**, and **hypermobile (ΔSS > 30°)**.

All radiographic measurements were performed independently by two observers blinded to clinical outcomes. Inter-observer reliability was assessed using the intraclass correlation coefficient (ICC).

Surgical Technique

All procedures were performed by experienced arthroplasty surgeons using a **standardized surgical protocol**. Patients were positioned in the **lateral decubitus position**, and a **posterior approach** to the hip was utilized in all cases (modify if required).

Following exposure, the femoral head was excised and the acetabulum was prepared using sequential reaming. **Cementless acetabular components** were implanted in all patients. Acetabular cup positioning aimed for a target inclination of **40° ± 10°** and anteversion of **15° ± 10°**, based on intraoperative anatomical landmarks. Femoral preparation was performed using standard broaching techniques, and **cementless femoral stems** were implanted in all cases. Femoral head size was selected according to patient anatomy and intraoperative stability assessment.

Trial reduction was performed to assess hip stability, leg length equality, and range of motion. Final components were implanted after satisfactory trialing. Posterior soft tissue repair was performed in all patients to enhance stability. Wound closure was completed in layers over a suction drain as required.

All patients received standardized perioperative antibiotic prophylaxis and thromboprophylaxis in accordance with institutional protocols.

Postoperative Rehabilitation

All patients followed a **standardized postoperative rehabilitation protocol**. Mobilization was initiated on the **first postoperative day** with full weight bearing as tolerated using walking aids. Hip precautions appropriate to the surgical approach were advised for the initial **6 weeks**.

Physiotherapy focused on progressive range-of-motion exercises, strengthening of the hip abductors and extensors, and gait training. Patients were encouraged to gradually return to activities of daily living under supervision. Thromboprophylaxis and antibiotic prophylaxis were administered according to institutional protocols.

Rehabilitation protocols were identical for all patients to minimize variability in functional outcomes.

Outcome Measures

Primary Outcome Measure

- **Functional improvement** following total hip arthroplasty, assessed using the **Harris Hip Score (HHS)** at **4 months postoperatively**.

Secondary Outcome Measures

- **Pain intensity**, evaluated using the **visual analog scale (VAS)** at 4 months postoperatively.
- **Postoperative instability**, defined as occurrence of hip dislocation or subluxation during the follow-up period.
- **Postoperative complications**, including surgical site infection, thromboembolic events, periprosthetic fracture, and need for reoperation.

Follow-up

All patients were followed prospectively after surgery and evaluated at **6 weeks, 3 months, and 4 months** postoperatively. The **4-month visit served as the final follow-up** for clinical and functional outcome assessment.

At each follow-up visit, patients underwent clinical examination and assessment of functional outcome measures and pain scores. Postoperative complications and instability events were recorded throughout the follow-up period.

Statistical Analysis

Statistical analysis was performed using **Statistical Package for the Social Sciences (SPSS), version 26.0** (IBM Corp., Armonk, NY, USA). Data were assessed for normality using the **Shapiro–Wilk test**. Continuous variables were expressed as **mean ± standard deviation** for normally distributed data and as **median with interquartile range** for non-normally distributed data. Categorical variables were presented as **frequencies and percentages**.

Baseline demographic and clinical variables were compared across spinopelvic mobility groups (stiff, normal, and hypermobile). **One-way analysis of variance (ANOVA)** was used for normally distributed continuous variables, and the **Kruskal–Wallis test** was applied for non-parametric data. Categorical variables were analyzed using the **Chi-square test** or **Fisher's exact test**, as appropriate.

Within-group changes in functional and pain scores from preoperative assessment to 4 months postoperatively were evaluated using the **paired t-test** or **Wilcoxon signed-rank test**, as appropriate. Between-group differences in functional improvement were assessed using **ANOVA with Bonferroni post-hoc correction**.

A **multivariable linear regression analysis** was performed to identify independent predictors of functional improvement, adjusting for age, sex, body mass index, and primary diagnosis. Results were

reported as beta coefficients with 95% confidence intervals.

A **p-value < 0.05** was considered statistically significant.

RESULTS

Study Population

A total of 50 patients undergoing primary total hip arthroplasty were prospectively enrolled and completed a 4-month follow-up. The mean age was 57.9 ± 8.7 years (range 39–74). There were 29 males (58%) and 21 females (42%). Primary osteoarthritis was the most common indication (64%), followed by avascular necrosis (28%).

Spinopelvic Mobility Distribution

Based on change in sacral slope (ΔSS), patients were categorized into three mobility groups. Normal spinopelvic mobility was observed in 56% of patients.

Table 1: Distribution of Spinopelvic Mobility

Spinopelvic mobility	ΔSS definition	Number of patients	Percentage
Stiff	ΔSS < 10°	12	24%
Normal	ΔSS 10°–30°	28	56%
Hypermobile	ΔSS > 30°	10	20%
Total	—	**50**	**100%**

Mean ΔSS for the entire cohort was **22.1 ± 10.8°**.

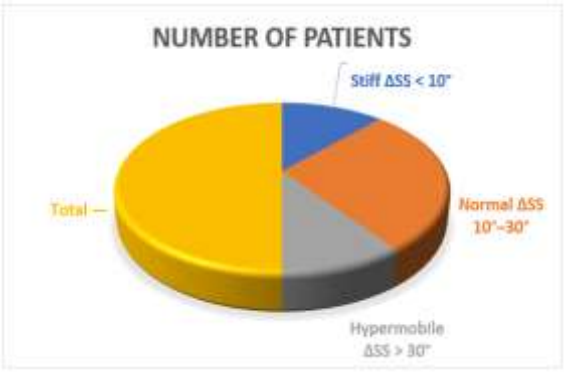

Figure 1: Notes

Bar chart illustrating the distribution of patients according to spinopelvic mobility based on the change in sacral slope (ΔSS). Of the 50 patients, 24% had stiff mobility, 56% had normal mobility, and 20% were hypermobile.

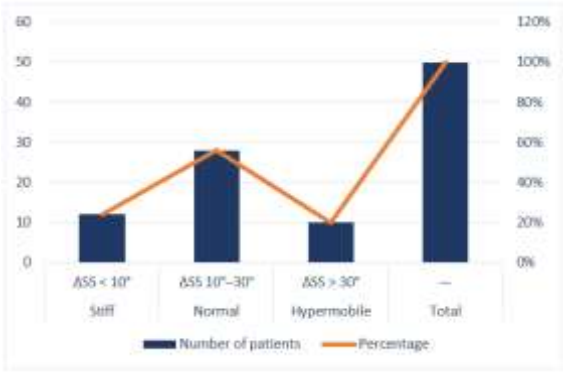

Figure 2: Notes

Bar graph depicting the distribution of patients according to spinopelvic mobility based on the change in sacral slope (ΔSS). Of the 50 patients, 24% demonstrated stiff mobility, 56% normal mobility, and 20% hypermobile mobility.

Functional Outcomes

The Harris Hip Score (HHS) improved significantly in all groups at 4 months postoperatively. Patients with normal spinopelvic mobility demonstrated the greatest functional improvement.

Table 2: Harris Hip Score by Spinopelvic Mobility

Mobility group	Preoperative HHS (Mean ± SD)	4-month HHS (Mean ± SD)	Mean improvement
Stiff (n = 12)	44.5 ± 7.2	78.6 ± 7.9	34.1 ± 8.8
Normal (n = 28)	45.9 ± 8.0	88.1 ± 6.7	42.2 ± 8.1
Hypermobile (n = 10)	46.3 ± 7.5	82.7 ± 7.2	36.4 ± 9.0

Between-group comparison: *p = 0.004* (one-way ANOVA)

Pain Outcomes

VAS pain scores improved significantly from 7.5 ± 1.0 preoperatively to 1.9 ± 0.8 at 4 months ($p < 0.001$). Greater pain reduction was observed in the normal mobility group ($p = 0.03$).

Complications and Instability

Postoperative complications were observed in 4 patients (8%). Hip dislocation occurred in 2 patients (4%), both belonging to abnormal mobility groups.

Table 3: Postoperative Complications by Spinopelvic Mobility

Complication	Stiff (n=12)	Normal (n=28)	Hypermobile (n=10)	Total
Hip dislocation	1	0	1	2 (4%)
Surgical site infection	0	0	0	0
Thromboembolic event	0	0	0	0
Periprosthetic fracture	0	0	0	0

Table Notes

Values are presented as number of patients. Postoperative complications were recorded during the 4-month follow-up period. Hip dislocation occurred only in patients with abnormal spinopelvic mobility, while no cases of deep infection, thromboembolic events, periprosthetic fracture, or revision surgery were observed.

DISCUSSION

The present prospective single-center study evaluated the impact of preoperative spinopelvic mobility on early functional outcomes following total hip arthroplasty. The principal finding of this study was that patients with normal spinopelvic mobility achieved significantly greater functional improvement at 4 months postoperatively compared with those with stiff or hypermobile mobility patterns. These results highlight the clinical relevance of spinopelvic mechanics in influencing early recovery after THA.[5,8]

Spinopelvic motion plays a crucial role in determining functional acetabular orientation during postural changes.[4,6] Patients with stiff spinopelvic mobility demonstrate limited posterior pelvic tilt during sitting, which may lead to altered functional anteversion of the acetabular component and increased risk of impingement.[10] This biomechanical constraint likely contributes to the reduced functional improvement observed in the stiff mobility group in the present study. Conversely, excessive motion in hypermobile patients may result in greater variability in functional cup orientation, potentially compromising stability during activities involving extension or flexion.[2,11]

Previous studies have primarily focused on the association between abnormal spinopelvic mobility and postoperative instability or dislocation.[1,13]

The findings of the present study expand upon existing literature by demonstrating that spinopelvic mobility also significantly affects early patient-reported functional outcomes, even in the absence of major complications.[14,15] The higher incidence of postoperative dislocation observed in patients with abnormal mobility further supports the importance of preoperative spinopelvic assessment.[7,9]

The use of standardized standing and seated lateral radiographs allowed for practical and reproducible assessment of spinopelvic mobility.[3,12] This method can be easily incorporated into routine preoperative evaluation without additional cost or radiation exposure. Identifying patients with abnormal spinopelvic mobility preoperatively may assist surgeons in optimizing acetabular component positioning and in counseling patients regarding expected postoperative recovery.[4,5]

The present study has several limitations. The relatively small sample size and single-center design may limit the generalizability of the findings. The follow-up duration of 4 months represents early outcomes and does not capture long-term functional results or implant survivorship.[9,10] Additionally, patients with prior lumbar spine fusion were excluded, which may limit applicability to populations with significant spinal pathology.[8]

Despite these limitations, the prospective design, standardized surgical and rehabilitation protocols, and uniform outcome assessment strengthen the validity of the study. Future studies with larger cohorts and longer follow-up are warranted to further clarify the long-term implications of spinopelvic mobility on functional outcomes and implant stability following THA.[13,14]

CONCLUSION

This prospective single-center study demonstrates that preoperative spinopelvic mobility has a significant influence on early functional outcomes following total hip arthroplasty. Patients with normal spinopelvic mobility achieved greater improvement in Harris Hip Score at 4 months postoperatively, while those with stiff or hypermobile mobility patterns showed comparatively reduced functional recovery and a higher incidence of postoperative instability.

Routine preoperative assessment of spinopelvic mobility using standing and seated lateral radiographs is a simple and practical tool that may aid in identifying patients at risk for suboptimal early outcomes. Incorporating spinopelvic evaluation into preoperative planning may assist surgeons in optimizing acetabular component positioning, improving early functional recovery, and enhancing patient counseling.

REFERENCES

1. Haffer H, Wang Z, Hu Z, et al. Total hip replacement influences spinopelvic mobility: A prospective observational study. J Arthroplasty. 2021.
2. Louette S, Wignall A, Pandit H. Spinopelvic relationship and its impact on total hip arthroplasty. Arthroplasty Today. 2022
3. Crawford AM, Cronin PK, Lange JK, Kang JD. Spinopelvic mobility as it relates to THA cup positioning. Orthop J Harvard Med Sch. 2020.
4. Schuller S, et al. The spinopelvic relationship made simple. JSES Arthroplasty. 2019.
5. Grammatopoulos G, Innmann MM, Phan P, et al. Spinopelvic challenges in primary THA. EFORT Open Rev. 2023;8(5):298–312.
6. Attenello JD, Harpstrite JK. Implications of spinopelvic mobility on THA. Hawaii J Health Soc Welf. 2023.
7. Yun HH, Kim YB, Joo HJ, Koh YY. Does spinopelvic motion change after THA? Int Orthop. 2022
8. Vergari C, Kim Y, Takemoto M, et al. The relationship between spino-pelvic-hip mobility and quality of life before and after THA. Arch Orthop Trauma Surg. 2024;144:1379–1387.
9. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am. 1978;60(2):217–220.
10. Phan K, Bedair H, Schwarzkopf R, et al. Spinopelvic motion and acetabular component positioning. Int Orthop. 2017;41(11)
11. Heckmann ND, Lieberman JR. Spinopelvic biomechanics and THA. J Am Acad Orthop Surg. 2021;29(9)

12. Innmann MM, Verhaegen JCF, Reichel F, et al. Spinopelvic characteristics normalize after THA. J Bone Joint Surg Am. 2021
13. Esposito CI, Lee Y-Y, Pugely AJ, et al. Sagittal alignment impacts function after THA. Bone Joint J. 2020;102-B(9)
14. Gausden EB, Meneghini RM. Spinopelvic motion analysis improves THA component positioning. Bone Joint J. 2019;101-B(10)
15. Phan D, Pellicci PM, Sculco PK, et al. Functional safe zones in THA. J Arthroplasty. 2021;36(10).