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SPINOPELVIC MOBILITY IN PATIENTS WITH HIP OSTEOARTHRITIS AND TOTAL HIP ARTHROPLASTY INDICATION

MOBILIDADE ESPINOPÉLVICA NOS PACIENTES COM ARTROSE DO QUADRIL E INDICAÇÃO DE ARTROPLASTIA TOTAL

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ABSTRACT

Introduction: Reduction of spinopelvic mobility is associated with an increased dislocation of total hip arthroplasty (THA). Objective: To assess 1) spinopelvic mobility in patients with primary hip osteoarthritis and THA indication and 2) the influence of hip flexion contracture on spinopelvic mobility. Methods: Thirty adult patients with primary hip osteoarthritis and THA indication were evaluated using radiographic parameters (pelvic incidence, pelvic tilt, sacral slope, lumbar flexibility, and spinopelvic mobility). Results: Spinopelvic mobility ranged from 6.90 a 54.50° (mean 32.79 ± 11.42) and the group of patients with hip flexion contracture had higher mobility. Spinopelvic mobility was correlated with pelvic tilt as well as with lumbar flexibility. Conclusion: Around 13.4% of patients had spinopelvic mobility under 20° , indicating reduced spinopelvic mobility and risk of THA dislocation. ***Level of Evidence III, Retrospective Comparative Study.***

Keywords: Spine. Hip. Hip Contracture.

RESUMO

Introdução: A redução da mobilidade espinopélvica tem sido associada com o risco de luxação da prótese total do quadril. Objetivos: Avaliar a mobilidade espinopélvica nos pacientes com artrose primária da articulação do quadril e com indicação de artroplastia total do quadril (ATQ), e a influência da contratura em flexão do quadril sobre a mobilidade espinopélvica. Métodos: Trinta pacientes adultos com artrose primária do quadril e indicação de ATQ foram avaliados por meio de parâmetros radiográficos (incidência pélvica, versão pélvica, inclinação do sacro, mobilidade da coluna lombar e mobilidade espinopélvica). Resultados: A mobilidade espinopélvica variou de 6,90 a 54,50 graus (média 32,79 ± 11,42), e foi estatisticamente maior no grupo de pacientes com contratura em flexão do quadril. Foi observado correlação entre a mobilidade espinopélvica e a versão pélvica e flexibilidade da coluna lombar. Conclusão: A mobilidade espinopélvica abaixo de 20 graus, que caracteriza a redução da mobilidade espinopélvica e risco aumentado de luxação ou impacto dos componentes da prótese total foi observada em 13,4% dos pacientes. ***Nível de Evidência III, Estudo Retrospectivo Comparativo.***

Descritores: *Coluna Vertebral. Quadril. Contratura Quadril.*

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INTRODUCTION

Patients with spinal arthrodesis, degenerative disease, or spinal deformity have a higher rate of late dislocation after total hip arthroplasty (THA) (8-20%) compared to traditionally described rates (0.3-3%). This aroused the interest of researchers for studying spinopelvic mobility and parameters.[1,2]

The transition from orthostatic to sitting position occurs with posterior sacral slope, lumbar lordosis reduction, and pelvic retroversion with increased acetabular anteversion to accommodate the head of the flexed femur (Figure 1).[3,4] When changing from standing to sitting, each degree of pelvic retroversion increases acetabular anteversion in 0.8°.[2,3,5] The inability of posterior sacral slope and pelvic retroversion prevent a good accommodation of the femoral head, leading to its dislocation or acetabular shock.[2,3]

The orientation of the acetabulum is different in the orthostatic, sitting, and supine positions. However, the supine position has been classically used to perform imaging and positioning tests of the acetabular component during surgery.[5,6] Prosthesis dislocation has been reported in patients with correct positioning of implants in the "Lewinnek safe zone," which uses radiographs and anatomical references in the supine position.[2,7]

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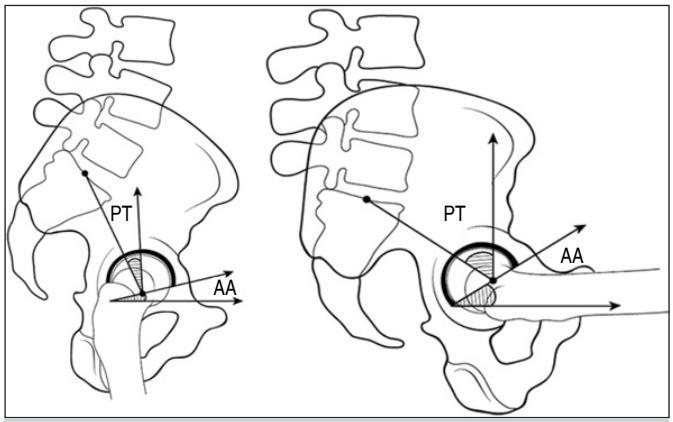

Figure 1. Drawing illustrating the positioning of the lumbar spine, sacrum, acetabulum, and femur in the orthostatic position (left) and sitting position (right).

In these patients, dislocation was caused by acetabular positioning, which has different orientation in the orthostatic, sitting, or supine positions along with the pelvis.[2,5,6] Most hip prosthesis dislocations occur while sitting[7] and variations in spinopelvic parameters in this position have become the subject of study and interest.[2,6,7]

The preoperative assessment of spinopelvic complex mobility and the behavior of the acetabular anteversion in the sitting position guides the positioning of the acetabular component during THA to avoid dislocation or shock of the prosthesis components.[5,6] Different anatomical references of the sacrum, pelvis bones, and femur have been used for angular measurement in the standing and sitting positions. The sacral slope (SS) between the orthostatic and sitting position on profile radiographs has been considered normal for 20-40° angular variation. Other parameters such as acetabular anteversion, sacro-acetabular angle, proximal femoral angle, and spinopelvic parameters have also been used to assess spinopelvic mobility and the positioning of the acetabulum or the acetabular component of the prostheses.[2,5,8]

This study was conducted to analyze the influence of spinopelvic mobility on the results of total hip arthroplasty. The study aimed to (a) assess preoperative spinopelvic mobility in patients with primary arthrosis of the hip joint and with indication of THA and (b) assess the influence of hip flexion contracture on spinopelvic mobility and its correlation with spinopelvic parameters (pelvic incidence, pelvic tilt, lumbar lordosis, lumbar lordosis flexibility).

MATERIAL AND METHODS

This observational and retrospective study was approved by the Research Ethics Committee of HCFMRP-USP no. 1515/2021. The study included 30 adults (over 18 years old) of both sexes with hip arthrosis, subjected to THA, and with no lumbar spine deformity or any previous lumbar or hip surgery.

Patients were evaluated preoperatively using clinical and radiological parameters. The Thomas test was used to assess hip flexion contracture. The radiographic parameters selected for the study were pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL), spinopelvic mobility, and lumbar flexibility (Figure 2). Spinopelvic mobility was assessed by different values of sacral slope (SS) on profile radiographs in the orthostatic and sitting positions. Lumbar spine flexibility was measured by different lumbar lordosis values in the orthostatic and sitting positions.

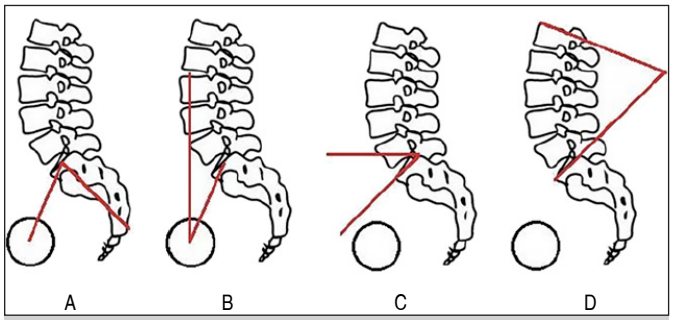

Figure 2. Spinopelvic parameters (A: pelvic incidence; B: pelvic tilt; C: sacral slope; D: lumbar lordosis).

The panoramic radiographs were taken in a standardized manner with patients in a comfortable standing position with the upper limbs flexed on top of a support. Sitting radiographs were taken with patients in a comfortable sitting position with knees flexed at 90°, feet resting on the ground, and without forcedly flexing the lumbar spine.

Radiographic parameters were measured using a program for image analysis (Surgimap – New York, USA). Two evaluators conducted the measurements (Figure 3).

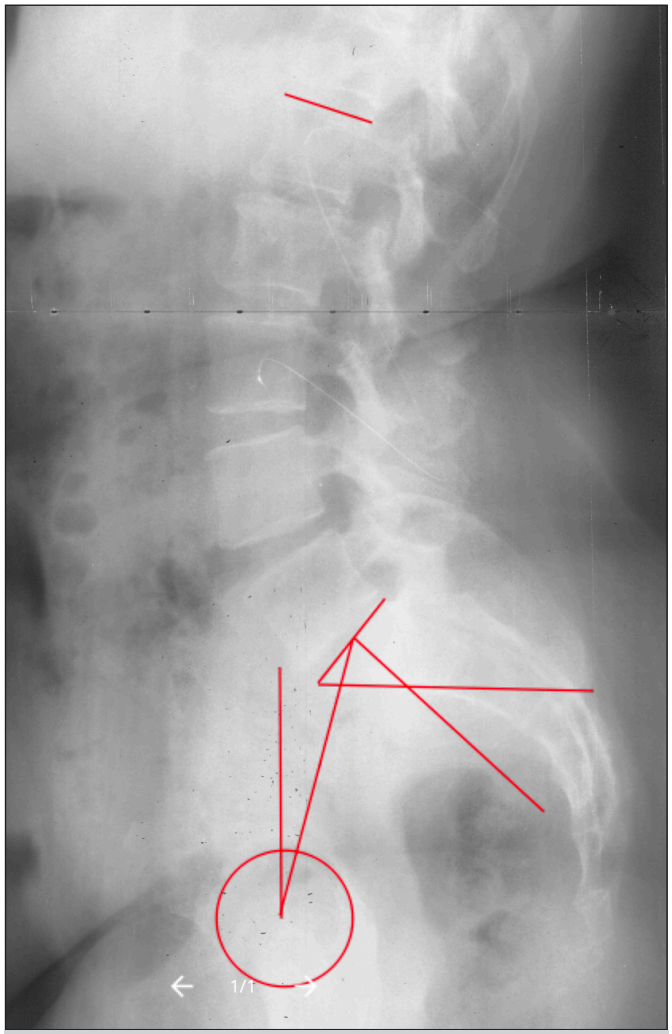

Figure 3. Profile radiographs illustrating references and measurements of spinopelvic parameters (pelvic incidence, pelvic tilt, sacral slope, and lumbar lordosis)

Descriptive statistics were performed for the quantitative variables (mean, standard deviation) and the Anderson-Darling test was conducted to assess sample normality. Group comparison was performed by Student's *t*-test for the parametric distribution groups. The reliability of the measures among the observers was estimated using Pearson's coefficient. The statistical tests adopted a significance level of 5% ($p < 0.05$).

RESULTS

Table 1 shows the demographic data and assessed parameters. The age of the patients ranged from 48 to 87 years (64.90 ± 10.19 years). Eighteen (60%) patients were male and 12 (40%) were female. The preoperative assessment conducted by Thomas test found that 14 patients had hip flexion contracture, ranging from 10 to 30° (Table 1).

A high degree of correlation (> 0.9) (Pearson's Coefficient) was observed between the radiographic parameter measurements of the two evaluators using the SURGIMAP software (Surgimap – New York, USA).

Table 1. Demographic data of patients and assessed parameters.

Patient	Sex	Age	Flexion contracture	PI	PT	SS	LL	Llorto-sem	ΔSS
1	Fem	70	30 and 30	58.6	11	47.6	55.8	61.9	41.1
2	Male	61	10 and 10	79.9	34.9	45	46.9	23.9	24.2
3	Fem	64	15 and 15	60.6	7.4	53.6	57	28.1	47.4
4	Fem	81	15 and 15	62.1	13.5	48.6	71.6	29.3	33.6
5	Fem	68	10 and 10	70.8	18.7	52.1	80.2	44.8	37.1
6	Male	76	20 and 20	50.9	-7.5	58.4	78.9	67.7	48.2
7	Fem	55	20 and 20	30.5	-12.3	42.8	61.3	47.6	41.5
8	Fem	56	10 and 10	77.6	20.5	57	75.6	48.4	38.6
9	Male	64	20 and 20	61.8	10.5	51.3	66.5	52	45.1
10	Fem	84	15 and 20	52.5	22.7	29.9	42	26.9	28.4
11	Male	64	15 and 15	52.1	14.3	37.8	64.9	54.7	37.4
12	Male	52	20 and 20	76.4	38.1	38.3	42.3	10.7	14.1
13	Male	62	20 and 20	59.9	11.7	48.2	73.7	41.7	31.1
14	Male	69	10 and 10-	53.2	19.9	33.2	48.4	35.1	54.5
15	Male	74	no	59	10.7	48.3	67.3	12.1	6.9
16	Fem	64	no	82.5	37.9	44.6	65.1	30.6	30.7
17	Male	66	no	56.7	6.9	49.8	65.6	38.1	30.4
18	Fem	87	no	43.4	22.9	20.5	-8.6	6.2	30.7
19	Male	52	no	75	28.3	46.7	48.5	13.8	21.6
20	Fem	76	no	67.3	21.3	46	74.3	42	27.6
21	Male	53	no	71.9	22.6	49.3	59.6	45.8	42.3
22	Fem	71	no	52	5.3	46.8	80.3	35.3	24.1
23	Male	68	no	57.4	2.7	54.7	69	63.4	48.3
24	Male	66	no	60.8	11.7	49.1	67.9	45.2	34.1
25	Male	50	no	65.2	22	43.1	49.6	23	14.4
26	Male	52	no	42.4	-4.8	47.2	50.4	34	38
27	Male	72	no	51.5	13.6	7.9	59.9	39.5	34.5
28	Male	48	no	74	24	50	72.4	48.4	33.8
29	Fem	65	no	54.6	9.1	45.5	67.6	24.8	12.1
30	Male	57	no	55.5	7.8	37.6	38.2	22.6	31.9

Spinopelvic mobility assessed by sacral slope (SS) variation in the orthostatic and sitting position ranged from 6.90 to 54.50° (mean 32.79 ± 11.42). Patients with and without hip flexion contracture had statistical differences in spinopelvic mobility values. Patients with hip flexion contracture (Thomas +) presented higher spinopelvic mobility ($p = 0.0404$ – Student's *t*-test) (Figures 4 and 5).

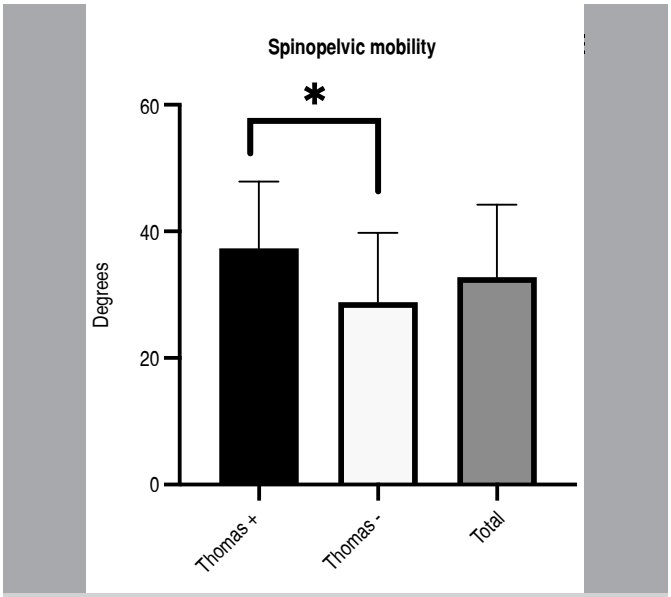

Figure 4. Graph illustrating the mean and standard deviation of spinopelvic mobility in patients with hip flexion contracture (Thomas +), without contracture (Thomas −), and in all patients. The asterisk (*) indicates statistical difference between groups (Student's *t*-test).

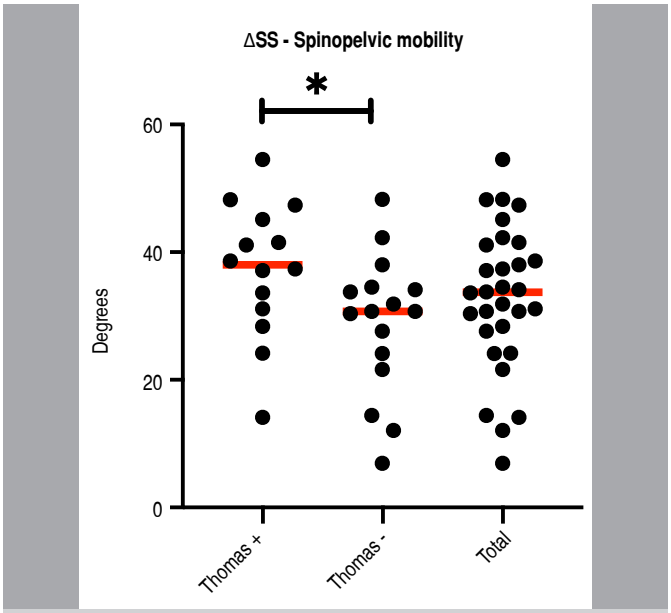

Figure 5. Graph illustrating the mean and standard deviation of spinopelvic mobility in patients with hip flexion contracture (Thomas +), without contracture (Thomas −), and in all patients. The asterisk (*) indicates statistical difference between groups (Student's *t*-test).

Spinopelvic mobility under 20°, considered as the lower limit and classified as spinopelvic stiffness, was observed in one (7.15%) patient with hip flexion contracture and in three (18.75%) patients with no contracture (Table 2).

Table 3 and Figures 6, 7, and 8 show the correlations of spinopelvic mobility with the assessed parameters. No correlation was observed between pelvic incidence (PI) and spinopelvic mobility (Pearson's coefficient $r = -0.2445$, $p = 0.1928$). Lumbar lordosis was also not correlated with spinopelvic mobility (Spearman's coefficient $r = 0.1273$, $p = 0.5027$).

Table 2. Distribution of the number and percentage of patients with hip contracture (Thomas +), without hip contracture (Thomas −), and of all patients according to spinopelvic mobility (orthostatic ΔSS and sitting SS).

	Thomas + pre-op. n (%)	Thomas - pre-op. n (%)	Total pre-op. n (%)
< 20°	1 (7.15)	3 (18.75)	4 (13.34)
20-40°	8 (57.14)	11 (68.75)	19 (63.33)
> 40°	5 (35.71)	2 (12.50)	7 (23.33)
Total	14 (100%)	16 (100%)	30 (100%)

Table 3. Correlation between spinopelvic mobility (Δ SS) and spinopelvic parameters.

Measure	PI	PT	LL	Δ LL
Δ SS	r = 0.2445	r = 0.3791*	r = 0.1273	r = 0.6877*

The asterisk (*) indicates statistical significance ($p < 0.05$).
PI: pelvic incidence; PT: pelvic tilt; LL: lumbar lordosis; Δ LL: lumbar lordosis flexibility.

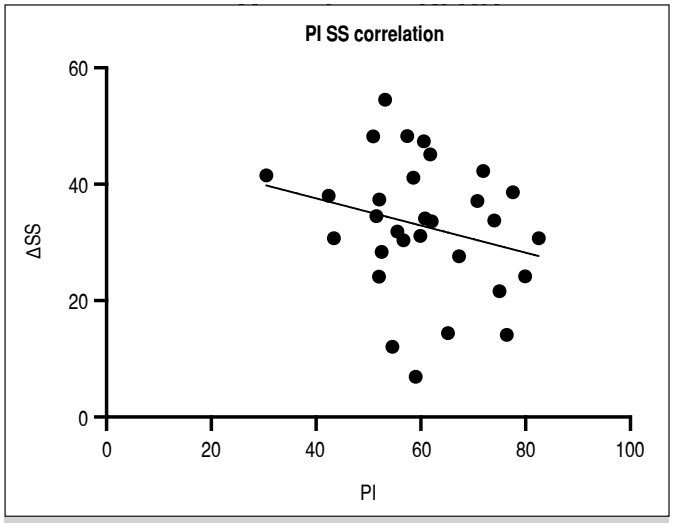

Figure 6. Graph illustrating the linear regression between spinopelvic mobility and pelvic incidence. No correlation was observed between pelvic incidence and spinopelvic mobility (Pearson's coefficient – $r = -0.2445$ – $p > 0.05$). Δ SS – spinopelvic mobility/ PI – pelvic incidence.

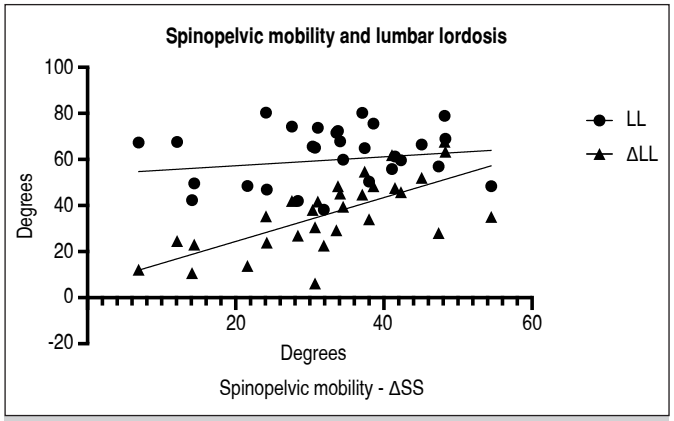

Figure 7. Graph illustrating the linear regression between spinopelvic mobility and lumbar lordosis (LL) and spinopelvic mobility and lumbar lordosis flexibility. Correlation was observed between spinopelvic mobility and lumbar lordosis flexibility (Pearson's coefficient – $r = 0.6877$, $p < 0.0001$). However, no correlation was observed between spinopelvic mobility and lumbar lordosis (Spearman coefficient – r = 0.1273-0.5027). LL – lumbar lordosis/ΔLL./ΔSS – spinopelvic mobility).

Correlation was observed between spinopelvic mobility and lumbar lordosis flexibility (Pearson's coefficient $r = 0.6877$, $p < 0.0001$) and pelvic tilt (Pearson's coefficient $r = -0.3791$, $p = 0.0388$) (Figures 7 and 8).

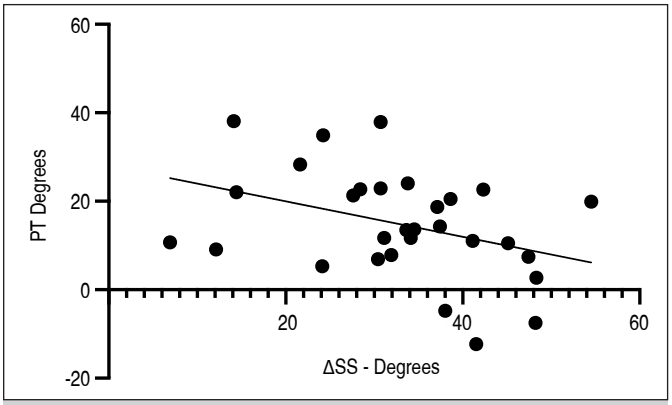

Figure 8. Graph illustrating the linear regression between spinopelvic mobility and pelvic tilt (PT). Correlation was observed between spinopelvic mobility and pelvic tilt (PT) (Pearson's coefficient – $r = -0.3791$, $p = 0.0388$). ΔSS – spinopelvic mobility.

DISCUSSION

Preoperative spinopelvic mobility varied significantly. Most patients (63%) presented mobility values between 20-40°, considered the physiological range;[5,6] about 13.4% of patients; however, they had spinopelvic mobility below 20°, which has been classified as stiffness. This percentage of patients with reduced spinopelvic mobility corroborates the reports in the literature, emphasizing the importance of mobility assessment before performing total hip arthroplasty.[2,4,5,9] The latter group of patients did not undergo lumbar spine surgery but had reduced spinopelvic mobility. The lumbar spine, pelvis, and hip present complex kinematic interaction. The inability of anterior rotation of the pelvis when changing from standing to sitting limits acetabular anteversion in these patients, inducing a greater flexion of the femur, which may dislocate or impact prosthesis components.[2,10]

Understanding how spinopelvic mobility affects the positioning of the acetabular component of the total hip prosthesis has shown that the "Lewinnek safe zone" (inclination of 40° ± 10° and anteversion of 15° ± 10°) does not consider acetabular positioning in different postures and its relationship with spinopelvic mobility.[8,11] Image assessment and arthroplasty conducted with the hip in supine position do not allow identifying changes in acetabular inclination in different positions. In dorsal decubitus with the lower limbs extended, the sacral slope (SS) increases in relation to the orthostatic and sitting positions, reducing acetabular anteversion.[2,3] To understand different acetabular positioning, the spinopelvic mobility and parameters obtained in the orthostatic and sitting positions must be assessed.[2,5,11]

Similarly to other studies,[2,10] our study assessed spinopelvic mobility using the difference of sacral slope (SS) in panoramic radiographs of the spine in the orthostatic and relaxed sitting positions. Some authors, however, argue that the forced sitting position, simulating the position of tying shoelaces, would be more sensitive for identifying changes not identified in the relaxed sitting position.[10] The literature diverges regarding the best assessment method of spinopelvic mobility; more sophisticated methods, such as biplanar stereoradiography, have also been used.[2,5,6]

To date, no scientific evidence is available on the normal and pathological limit of spinopelvic mobility.[2,5,8] The literature has previously

reported on the wide variation of values – as observed in our group of patients – and spinopelvic mobility has been classified as rigid, normal, and hypermobile.[6] The limits of normal values of spinopelvic mobility have ranged from 10 to 30°,[2,6,8] 20 to 40°,[5] and 20 to 35°,[12] showing that its physiological limits are still undefined.[2,10] Our studied group of patients had low values of spinopelvic mobility (< 20°), indicating stiffness. The possible implications of these values on arthroplasty results were commented. Spinopelvic hypermobility (> 40°) was also observed in our patients. The influence of this degree on the results of total hip prosthesis remains controversial.[2,10] Some reports indicate that THA reduces complications in patients with hypermobility,[13] whereas others associate hypermobility with lower results.[2,14] The physiological limits of spinopelvic mobility are still undefined, and the individual dynamic assessment of spinopelvic mobility should be considered.

Considering that hip flexion contracture can alter the interaction of the spinopelvic kinematic chain, we aimed to assess contracture influence on spinopelvic mobility. Our results showed statistical difference of spinopelvic mobility in patients with hip flexion contracture, who presented higher values than the control group. Compensatory mechanisms occur in this spinopelvic kinematic chain. Studies show that patients with lumbar spine stiffness increase the range of hip movements whereas patients with hip joint stiffness increase the range of lumbar spine movements.[6,10] Our study considered only sacral slope (SS), while other parameters related to spinopelvic movements, such as femoropelvic angle, femoral tilt, and others should be further analyzed together. The influence of joint contracture is still incipient in the literature despite being mentioned in the initial publication of Lazenec,[3] who first reported the influence of spinopelvic mobility and parameters on THA results. In the final phases of hip arthrosis, 80% of patients used lumbar spine mobility when changing from standing to sitting position, 10% mainly used the hip, and 10% mainly used the lumbar spine. Patients who mainly used the hip would have a higher risk of complications for not presenting compensatory mobility of the lumbar spine.[2,5]

Spinopelvic parameters were positively correlated with lumbar lordosis mobility and negatively correlated with pelvic tilt (PT). Considering that pelvic tilt increases during the transition from standing to sitting, reduced tilt indicates lower spinopelvic mobility, whereas increased tilt indicates hypermobility. Similarly to pelvic incidence (PI), lumbar lordosis alone was not correlated with pelvic mobility. However, lumbar lordosis mobility was correlated with pelvic mobility, corroborating the importance of lumbar spine mobility in spinopelvic mobility and its reduction in patients with arthrodesis or degenerative disease of the lumbar spine.[2,5,15]

This study presented limitations related to the small sample size due to difficulties in patient recruitment. Hip joint could also have been better analyzed. Patients with hip arthrosis had lower pelvic-femoral angle values and greater posterior femoral tilt.[12,15,16] Hip mobility can be assessed by comparing the values in the standing and sitting positions and measuring the position of the acetabular component (anterior inclination) and the femur (pelvic-femoral angle). The sum of these two parameters, called "combined sagittal index," has been used to determine the safe zone of acetabular component positioning.[11,12] In the kinematic chain of spinopelvic movements, changes are reciprocal. Lumbar spine stiffness increases hip movement, whereas hip joint stiffness increases the range of lumbar spine movements; both are relevant to positioning and adapting the acetabular component of the prosthesis.[2,3,5,11] These alterations are not homogeneous. Evidence shows that 80% of patients with advanced degree of hip arthrosis use the movements of both hips when changing from standing to sitting position, 10% mainly use the hip, and 10% mainly use the lumbar spine.[2,5] The detailed assessment of hip range of motion and its adaptations could clarify the behavior of spinopelvic mobility and adaptation. Future studies should therefore include it in their protocol.

Furthermore, this study did not consider the sagittal balance of the spine and other spinopelvic parameters since it aimed to analyze preoperative spinopelvic mobility in patients with hip arthrosis specifically. The study did not seek to assess the possible complications of THA but the changes in spinopelvic mobility in patients with hip arthrosis and subjected to total arthroplasty. Some patients showed significant variation and reduction of spinopelvic mobility, corroborating literature reports. Reduced spinopelvic mobility is a predictive factor of the late complications of total hip arthroplasty,[2,4,5,17] and a warning sign for the positioning of the acetabular component of THA. The results evidence the reduction of spinopelvic mobility in patients who did not undergo lumbar spine arthrodesis, reinforcing the current concept of assessing spinopelvic mobility and parameters before THA to avoid the complications observed in patients with lumbar spine stiffness.

CONCLUSION

The spinopelvic mobility of patients with primary hip arthrosis and indication of total arthroplasty varied significantly. Around 13.4% of patients presented spinopelvic mobility below 20°. Spinopelvic mobility > 20°, characterizing stiffness, may be associated with a higher risk of dislocation or impact of prosthesis components. Additional studies with bigger samples should seek to better understand the complex dynamic interaction between the lumbar spine, pelvis, and hip before and after THA.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. FLG: study design, data collection, writing of the article, data analysis, project review, intellectual concept, and article review; GPP: study design, data collection, writing of the article, data analysis, project review, intellectual concept, and article review; HLAD: study design, data analysis, and project review.

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