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■ HIP

Hip-lumbar mobility loss affects quality of life in patients undergoing both lumbar fusion and total hip arthroplasty

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Aims

Overall sagittal flexion is restricted in patients who have undergone both lumbar fusion and total hip arthroplasty (THA). However, it is not evident to what extent this movement is restricted in these patients and how this influences quality of life (QoL). The purpose of this study was to determine the extent to which hip-lumbar mobility is decreased in these patients, and how this affects their QoL score.

Methods

Patients who underwent primary THA at our hospital between January 2010 and March 2021 were considered ($n = 976$). Among them, 44 patients who underwent lumbar fusion were included as cases, and 44 THA patients without lumbar disease matched by age, sex, and BMI as Control T. Among those who underwent lumbar fusion, 44 patients without hip abnormalities matched by age, sex, and BMI to the cases were considered as Control F. Outcome and spinopelvic parameters were measured radiologically in extension and flexed-seated positions. Hip, lumbar, and hip-lumbar mobility were calculated as parameter changes between positions.

Results

There were 20 male and 112 female patients in the case and control groups, with a mean age of 77 years (5 to 94) and a mean BMI of 24 kg/m² (15 to 34). QoL score and hip-lumbar mobility were reduced in cases compared to Control T and F, and were further reduced as the number of fused levels increased. Hip-lumbar mobility was associated with reduction in activity-related QoL, mostly for those activities requiring sagittal flexion.

Conclusion

This study confirmed that hip-lumbar mobility is a factor that influences activity, most of all those requiring overall sagittal flexion. Clinicians should focus on hip-lumbar mobility and counteract disability by suggesting appropriate assistive devices.

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Introduction

Total hip arthroplasty (THA) is currently the most efficient procedure for patients with end-stage hip osteoarthritis to reduce pain, and improve physical function and quality of life (QoL).^{1–3} On the other hand, spinal fusion procedures are widely used to treat trauma, degenerative diseases of the spine, and spinal deformities, providing excellent clinical results in terms of pain and functional disability.⁴ However, lumbar fusion can decrease spinal mobility.⁵ In recent years, the number of patients undergoing both spinal fusion and THA

has grown with the increase in healthy life expectancy.^{6,7} This topic is often debated, especially in relation to complications such as dislocation after THA. However, there are few studies in these patients describing the effect of lumbar stiffness following lumbar fusion on activities of daily living (ADLs).

A previous study showed that QoL was inferior in patients who underwent both lumbar fusion and THA compared to those who underwent THA only.⁸ One factor that may contribute to inferior QoL is the loss of overall sagittal flexion, which

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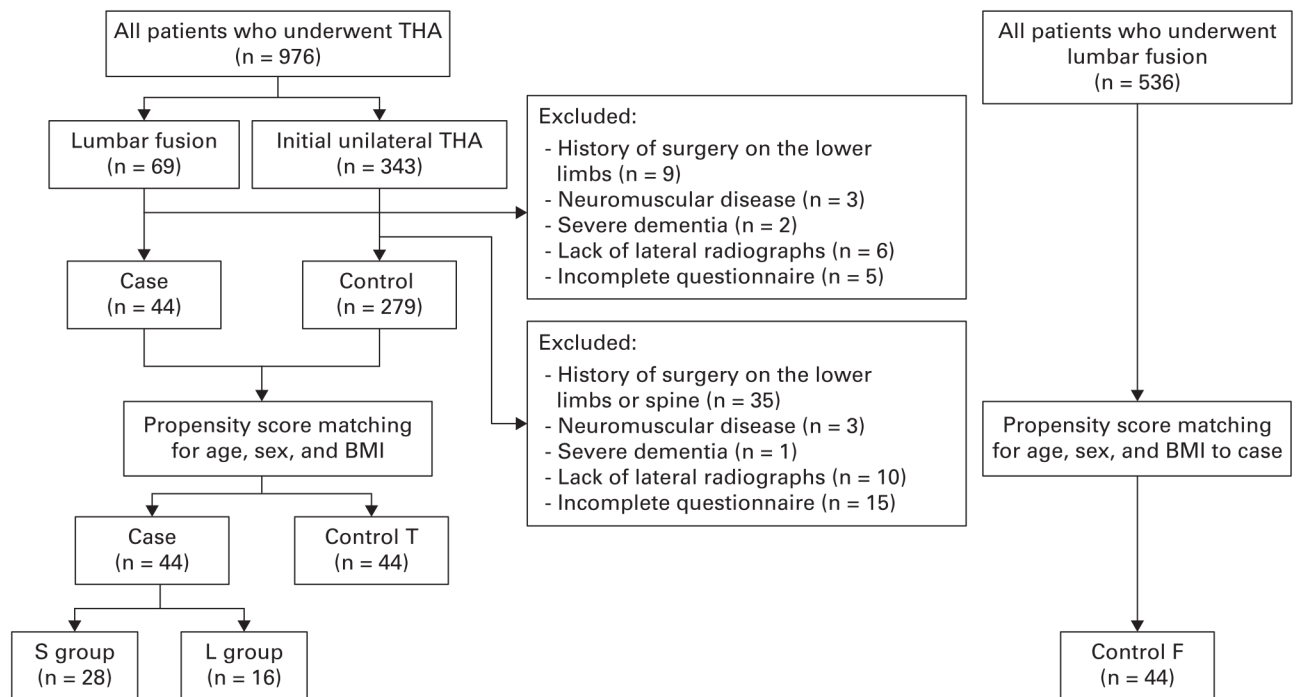


Fig. 1

Flowchart of patient selection. THA, total hip arthroplasty.

Table I. Patient demographic details.

Variable	Case	Control T	Control F	p-value	S group	L group	p-value	Volunteers
Patients, n	44	44	44		28	16		136
Mean age, yrs (range)	76 (52 to 89)	79 (63 to 94)	77 (51 to 88)	0.287*	75 (52 to 89)	78 (61 to 88)	0.440†	38 (11)
Sex, n (%)				0.422‡			0.117‡	
Female	36 (82)	40 (91)	36 (82)		25 (89)	11 (69)		94 (69)
Male	8 (18)	4 (9)	8 (18)		3 (11)	5 (31)		42 (31)
Mean BMI, kg/m ² (range)	24 (17 to 32)	23 (15 to 34)	24 (16 to 33)	0.244§	24 (17 to 32)	24 (18 to 29)	0.637¶	22 (3)
Standing PI, ° (range)	56 (33 to 80)	56 (40 to 83)	50 (30 to 75)	0.041§	55 (33 to 75)	59 (36 to 80)	0.240¶	52 (11)

*Kruskal-Wallis test.

†Mann-Whitney U test.

‡Fisher's exact test.

§One-way analysis of variance.

¶Independent-samples t-test.

PI, pelvic incidence.

is the sum of the lumbar and hip mobility.⁹ This reduction is due to decreased lumbar mobility following lumbar fusion and decreased hip mobility caused by hip osteoarthritis,^{10,11} and it can make ADLs, such as toenail cutting and the putting on/taking off socks, more difficult. However, it is unclear to what extent patients who have undergone both lumbar fusion and THA have decreased hip-lumbar mobility.

The purpose of this study was to determine whether patients who underwent both lumbar fusion and THA differ in a QoL score that includes toenail cutting and putting on/taking off socks, and to what extent lumbar and hip-lumbar mobility is limited in these patients compared to those who underwent THA or lumbar fusion only. A further purpose was to evaluate how lumbar and hip-lumbar mobility varies with the number of

fixed lumbar segments, and if this affects QoL score in patients undergoing both lumbar fusion and THA.

Our hypothesis is that patients who underwent both lumbar fusion and THA will have significantly inferior QoL scores and decreased lumbar and hip-lumbar mobility, compared to patients who underwent THA or lumbar fusion only. Also, hip-lumbar mobility and the number of fixed levels may be factors that influence disability in toenail cutting and putting on/taking off socks.

Methods

This was a retrospective case-control-matched study. This study was in compliance with the Declaration of Helsinki,¹² and has been approved by the institutional ethics board (authorization

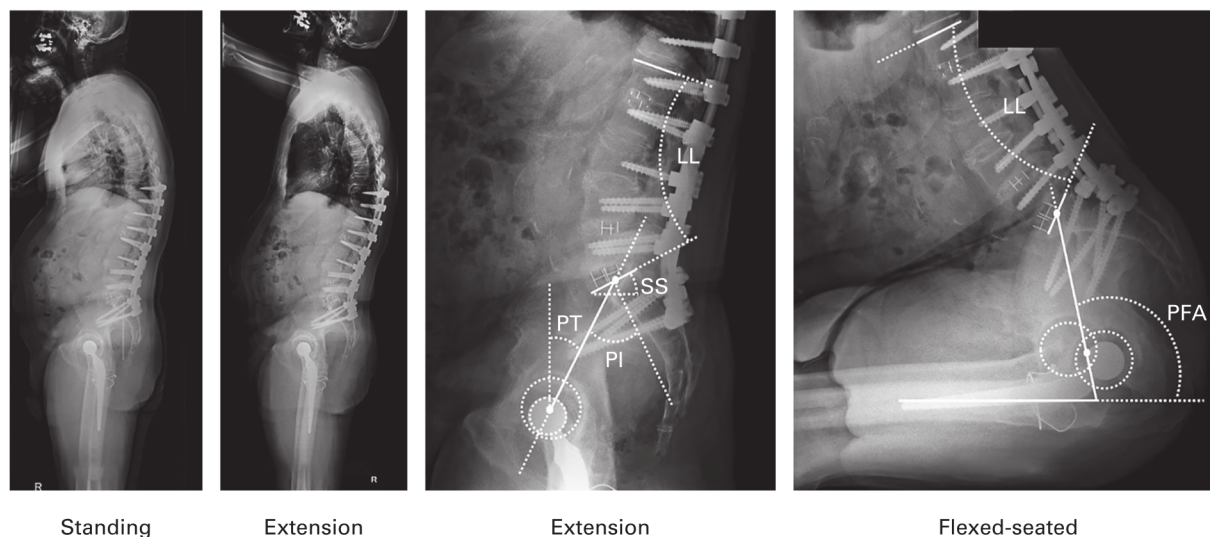


Fig. 2

Illustration of radiological measurements of spinopelvic parameters in functional lateral radiographs. Spinopelvic parameters are: L1-S1 lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), and pelvic-femur angle (PFA).

Table II. Patient-reported outcomes.

Variable	Case	Control T	Control F	p-value	S group	L group	p-value	Volunteers
Patients, n	44	44	44		28	16		136
Mean JHEQ (range)								
Pain	20 (1 to 28)	24 (7 to 28)	22 (4 to 28)	0.103*	22 (1 to 28)	18 (5 to 28)	0.071†	27 (2)
Movement	10 (0 to 28)	16 (2 to 28)	14 (1 to 28)	0.002*	11 (0 to 28)	6 (0 to 17)	< 0.05†	27 (2)
Mental	17 (1 to 28)	21 (2 to 28)	21 (0 to 28)	0.019*	19 (3 to 28)	13 (1 to 28)	< 0.05†	27 (2)
Total	47 (10 to 81)	60 (14 to 84)	57 (12 to 84)	0.007*	52 (10 to 81)	37 (12 to 69)	< 0.05†	82 (4)

*Kruskal-Wallis test.

†Mann-Whitney U test.

JHEQ, Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire.

705). Patients who underwent both lumbar fusion and THA (case), patients who underwent THA only without lumbar disease (Control T), and patients who underwent lumbar fusion only without hip abnormalities (Control F) were included. Exclusion criteria were: incomplete filling in of the questionnaire, severe dementia, neuromuscular diseases, any lateral radiographs not available, previous surgery on the lower limbs, and THA or spinal procedure performed within 12 months of the study's initiation. Cases and controls were matched for age, sex, and BMI, factors that have been reported to influence sagittal plane dynamics.¹³

Lumbar fusion-THA group. A total of 976 patients who underwent primary THA between January 2010 and March 2021 were retrospectively identified at our institution. There were 69 patients who had undergone lumbar fusion. Of these 69 patients, those with neuromuscular disease (n = 3), history of surgery on the lower limbs (n = 9), severe dementia (n = 2), lack of lateral radiographs (n = 6), or incomplete questionnaire (n = 5) were excluded (Figure 1). The remaining 44 patients were the cases for this study. One of the most common diagnoses of THA was osteoarthritis (39 of 44 patients (89%)). Lumbar fusion was performed at one level (n = 16), two levels (n = 12), three levels (n = 5), four levels (n = 3), and five or more levels

(n = 8). These cases were divided into two groups according to the extent of lumbar fusion: S group for one to two fused levels, and L group for three or more levels (Figure 1). Of the L group, 11 patients (70%) had all lower lumbar vertebrae fixed. Overall, 27 patients (61%) underwent THA prior to lumbar fusion, and 17 patients (39%) after.

THA-only group. Of the patients who underwent THA within the above time period, 343 had an initial unilateral THA. Those presenting neuromuscular disease (n = 3), history of surgery on the lower limbs or spine (n = 35), severe dementia (n = 1), lack of lateral radiographs (n = 10), or incomplete questionnaire (n = 15) were excluded. Of the remaining 279 patients, 44 patients matched by age, sex, and BMI with propensity scores in the case were the Control T for this study (Figure 1). The most common diagnoses for patients undergoing THA was osteoarthritis (36 of 44 (82%)).

Lumbar fusion-only group. A total of 536 patients who underwent lumbar spinal fusion surgery between January 2016 and March 2021 were included. Of these 536 patients, 44 patients matched for age, sex, and BMI with propensity scores in the case were considered Control F in this study. In these patients, a senior hip surgeon (YK) confirmed the absence of abnormalities in any of the hips, including narrowing of the

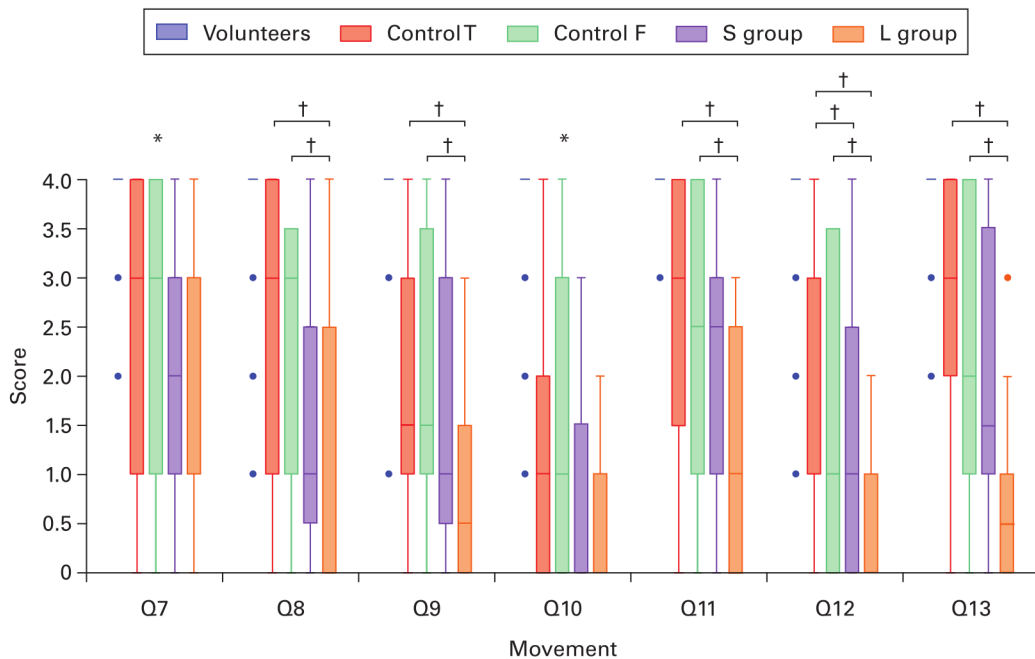


Fig. 3

The impact of the fixed levels on each movement item. Q7: going up and down stairs. Q8: getting up from the floor. Q9: crouching. Q10: use of crouching toilets. Q11: getting in/out of the bathtub. Q12: toenail cutting. Q13: socks putting on/taking off. *Significant difference after Kruskal-Wallis testing but not after pairwise comparisons with the Steel-Dwass test. †Significant difference after both Kruskal-Wallis testing and pairwise comparisons with the Steel-Dwass test.

joint space and the presence of osteophytes (Tönnis grade ≥ 2).¹⁴ Lumbar fusion was performed at one level ($n = 9$), two levels ($n = 6$), three levels ($n = 8$), four levels ($n = 4$), and or more levels ($n = 17$).

Volunteers. An additional control group of healthy volunteers was added retrospectively. This cohort was included in a previously published study.¹⁵

Assessment of clinical outcomes. Outcome assessment used the Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ) score at the time of radiological evaluation as the patient-reported outcome measures.^{16,17} The JHEQ is a self-administered questionnaire that consists of pain (28 points, increasing with decreasing pain), movement (28 points), and mental (28 points) subscales, with higher scores indicating a better outcome (but for pain). Each item is scored between 0 and 4 points, and the maximum total score is 84 points. The JHEQ is the Japanese version of the hip disease-specific scale, which has been shown to have higher validity and reliability compared to the 36-item Short Form Health Survey and the Oxford Hip Score (OHS).^{16,17}

We used the JHEQ Q12 (toe nail cutting) and Q13 (putting on/taking off socks) items, classifying two groups: a 'with disability' group for scores of 0 or 1, and a 'without disability group' for scores of 2 or higher. This classification was performed with a mix of cases and controls.

Data collection and radiological analysis. Functional lateral radiographs were obtained in free standing, extension, and flexed-seated positions (Figure 2). For the standing radiograph, patients were advised to stand and look forward with their fists

overlying ipsilateral clavicles.¹⁸ For the extension radiograph, patients were asked to hold onto a horizontal bar slightly higher than shoulder level and extend their pelvis and spine as much as possible (Figure 2).^{11,19} Flexed-seated position is defined as a sitting position in which the femora are parallel to the floor with the trunk leaning maximally forward.²⁰

From these radiographs, spinopelvic alignment parameters were measured, including pelvic incidence (PI), L1-S1 lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), and pelvic-femur angle (PFA). PFA was measured as the angle between the proximal femoral axis and the line connecting the centre of the femoral heads and the midpoint of the sacral endplate (Figure 2).^{11,15} The hip and lumbar mobility was calculated as the changes between the extension position and the flexed-seated position:

$$\Delta X_{\text{extension/flexed-seated}} = X_{\text{flexed-seated}} - X_{\text{extension}}$$

Lumbar mobility was defined as the difference in LL between the extension and flexed-seated positions (ΔLL). Hip mobility was defined as the difference in PFA between the extension and flexed-seated positions (ΔPFA). Hip-lumbar mobility was defined as the sum of the lumbar and hip mobility ($\Delta LL + \Delta PFA$).

Power analysis. We conducted power analyses using G*Power 3.1.9.7 software (Heinrich Heine University, Germany). For the comparison between the case, Control T, and Control F groups, we conducted a post-hoc power analysis for a one-way analysis of variance (ANOVA). With $\alpha = 0.05$ and a total sample size

Table III. Spinopelvic parameters.

Variable	Case	Control T	Control F	p-value	S group	L group	p-value	Volunteers
Patients, n	44	44	44		28	16		136
Mean parameter, ° (range)								
LL								
Extension	45 (0 to 80)	51 (-5 to 78)	42 (22 to 68)	0.013†	50 (16 to 80)	36 (0 to 68)	0.018‡	62 (11)
Flexed-seated	13 (-17 to 54)	4 (-19 to 31)	21 (-8 to 53)	< 0.001†	8 (-17 to 63)	22 (-12 to 54)	0.016‡	-9 (11)
SS								
Extension	28 (-13 to 53)	29 (11 to 49)	22 (9 to 40)	< 0.001*	31 (11 to 53)	22 (-13 to 41)	0.034§	35 (9)
Flexed-seated	49 (7 to 77)	51 (16 to 78)	66 (40 to 88)	< 0.001†	52 (9 to 77)	46 (7 to 72)	0.289‡	62 (14)
PT								
Extension	28 (3 to 84)	27 (6 to 62)	28 (14 to 50)	0.791*	23 (3 to 46)	37 (12 to 84)	0.002§	16 (9)
Flexed-seated	7 (-20 to 74)	4 (-30 to 35)	-16 (-42 to 10)	< 0.001*	3 (-20 to 65)	14 (-18 to 74)	0.104§	-9 (13)
PFA								
Extension	-14 (-57 to 4)	-13 (-48 to 16)	-19 (-36 to -2)	0.008*	-11 (-31 to 4)	-19 (-57 to 3)	0.029§	-13 (9)
Flexed-seated	79 (10 to 108)	80 (48 to 117)	104 (82 to 130)	< 0.001*	82 (10 to 108)	74 (12 to 106)	0.121§	103 (12)
Mean difference, ° (range)								
ΔLL	31 (2 to 65)	46 (10 to 80)	21 (0 to 62)	< 0.001†	41 (15 to 65)	14 (2 to 26)	< 0.001‡	71 (12)
ΔPFA	92 (12 to 126)	93 (57 to 122)	123 (103 to 152)	< 0.001*	92 (12 to 126)	92 (59 to 117)	0.740§	116 (11)
ΔLL + ΔPFA	123 (68 to 183)	139 (100 to 182)	144 (108 to 188)	< 0.001†	133 (68 to 183)	106 (74 to 127)	< 0.001‡	187 (14)

*Kruskal-Wallis test.

†One-way analysis of variance.

‡Independent-samples *t*-test.

§Mann-Whitney U test.

LL, L1-S1 lumbar lordosis; PFA, pelvic-femur angle; PT, pelvic tilt; SS, sacral slope.

Table IV. Spinopelvic parameters of patients with and without disability in toenail cutting and socks putting on/taking off activity.

Parameter	Toenail cutting		p-value	Putting on/taking off socks		p-value	Volunteers
	With disability	Without disability		With disability	Without disability		
Patients, n	77	55		55	77		136
Mean difference, ° (SD; range)							
ΔLL	27 (19; 0 to 68)	41 (17; 7 to 80)	< 0.001*	24 (18; 0 to 61)	40 (18; 1 to 80)	< 0.001†	71 (12)
ΔPFA	100 (22; 12 to 144)	106 (20; 57 to 152)	0.098*	100 (23; 12 to 139)	105 (21; 57 to 152)	0.300†	116 (11)
ΔLL + ΔPFA	127 (22; 68 to 183)	147 (17; 102 to 188)	< 0.001*	123 (21; 68 to 183)	144 (20; 102 to 188)	< 0.001*	187 (14)

*Independent-samples *t*-test.

†Mann-Whitney U test.

LL, L1-S1 lumbar lordosis; PFA, pelvic-femur angle.

of 132 (44 subjects per group), the calculated power was 0.84 (84%), while it was 69% for the comparison of S and L groups.

Statistical analysis. Propensity score matching was conducted using a logistic regression estimation algorithm, with nearest neighbour matching as the matching algorithm and a matching tolerance set at 0.2. After testing for normality (Shapiro-Wilk test), a one-way analysis of variance (ANOVA) or Kruskal-Wallis test was performed for the three group comparisons. An independent-samples *t*-test or Mann-Whitney U test was used for comparison between the two groups. The Fisher's exact test was used for categorical data. The Kruskal-Wallis test was used for the sub-analysis on clinical outcomes. If there was a significant difference, pairwise comparisons by the Steel-Dwass test were performed. To examine whether hip-lumbar mobility is a factor affecting disability in toenail cutting and putting on/taking off socks, multivariable logistic regression analysis was conducted. Odds ratios were calculated with 95% CIs. Cut-off values were calculated based on maximum sensitivity and specificity by performing a receiver operating characteristic

curve (ROC) analysis. Assessment of discriminative ability was done using the area under the curve (AUC). Significance level was set at $p < 0.05$, and data were reported as mean and range. Statistical analysis was performed using EZR v. 1.54 (Saitama Medical Centre, Jichi Medical University, Japan).

Results

There were 20 male and 112 female patients in the case and control groups, with a mean age of 77 years (51 to 94) and a mean BMI of 24 kg/m² (15 to 34). The patients were matched for age, sex, and BMI (Table I).

Clinical outcomes. A significant difference was found in JHEQ total score ($p = 0.007$), JHEQ movement score ($p = 0.002$), and JHEQ mental score ($p = 0.019$, all Kruskal-Wallis test) in the comparison between case, Control T, and Control F (Table II). The L group showed significantly lower JHEQ total score ($p = 0.018$), JHEQ movement score ($p = 0.028$), and JHEQ mental score ($p = 0.027$, all Mann-Whitney U test) than the S group (Table II). Sub-analysis focusing on the movement items

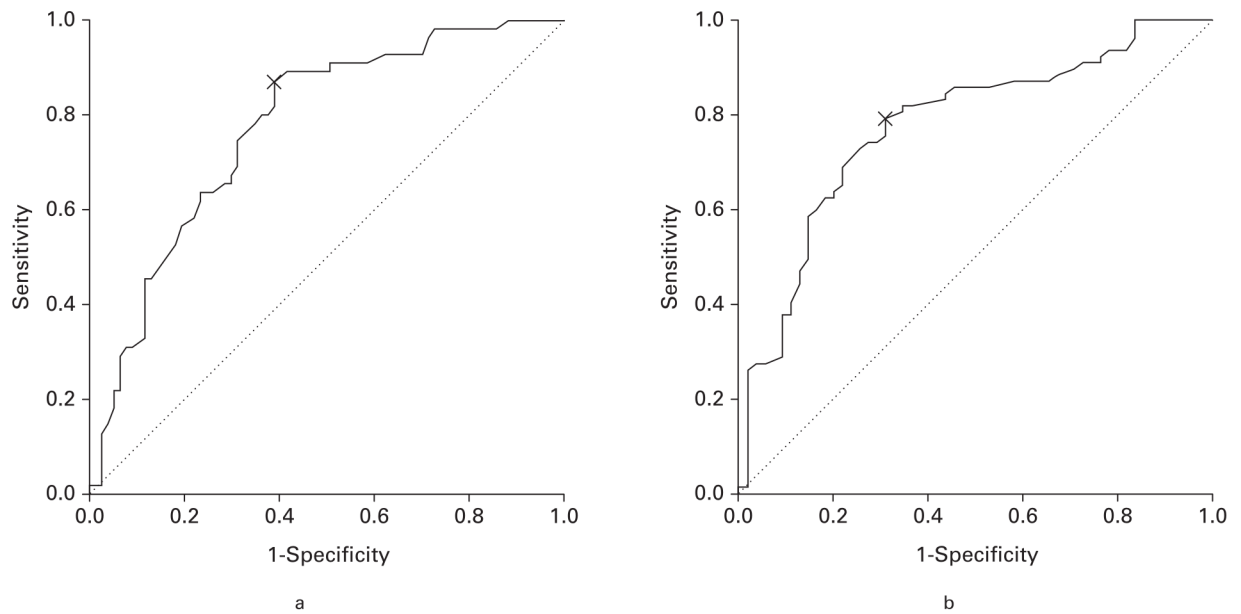


Fig. 4

Receiver operating characteristic curve analysis to determine the threshold of hip-lumbar mobility that decides with and without disability in a toenail cutting (area under the curve (AUC) 0.77) and b) putting on/taking off socks (AUC 0.78). The cross indicates the maximum sensitivity and specificity.

Table V. Association between toenail cutting and socks putting on/ taking off activities and hip-lumbar mobility.

Activity	OR (95% CI)	p-value
Toenail cutting		
Age	0.97 (0.92 to 1.03)	0.310
Sex	2.10 (0.68 to 6.97)	0.197
BMI	0.93 (0.82 to 1.04)	0.190
Hip-lumbar mobility	1.05 (1.03 to 1.08)	< 0.001
Putting on/taking off socks		
Age	0.97 (0.92 to 1.02)	0.296
Sex	1.34 (0.42 to 4.55)	0.622
BMI	0.94 (0.84 to 1.06)	0.313
Hip-lumbar mobility	1.05 (1.03 to 1.07)	< 0.001

OR, odds ratio.

showed that significant differences were found for most movement items in the comparison between the Control T or F and L groups, but no significant differences between the Control T or F and S groups (Figure 3).

Radiological assessment. There was a significant difference in lumbar mobility, hip mobility, and hip-lumbar mobility in the comparison between the three groups of case, Control T, and Control F (Table III). The L group with three or more fused levels had an even lower lumbar mobility and hip-lumbar mobility than the S group (one to two fused levels) (Table III). Full data are presented in Supplementary Table i.

Compared to the group without disability, in the toenail-cutting activity, the group with disability ($n = 77$) showed lower lumbar mobility and hip-lumbar mobility ($p < 0.001$, independent-samples t -test). Similarly, compared to the group without disability in the putting on/taking off socks activity, the

group with disability ($n = 55$) had lower lumbar mobility and hip-lumbar mobility ($p < 0.001$) (Table IV).

Multivariable logistic regression analysis demonstrated that hip-lumbar mobility was a factor affecting disability in toenail cutting and putting on/taking off socks, when adjusted for age, sex, and BMI (Table V). ROC analysis revealed that the cut-off value of hip-lumbar mobility for determining disability in the toenail-cutting activity was 130° (sensitivity 87%, specificity 61%) and in the putting on/taking off socks activity was 130° (sensitivity 79%, specificity 69%) (Figure 4).

Discussion

In recent years, there has been an increased interest in using functional lateral radiographs to assess lumbar, pelvis, with hip alignment and range of motion, in order to determine the impact of spinopelvic characteristics on dynamic behaviour and outcome after THA.^{10,21} However, it is not clear to what extent forward bending movements such as cutting toenails and putting on/taking off of socks are restricted, as objective values, compared to patients who underwent only a THA or lumbar spinal fusion. Our study has demonstrated that patients who underwent both lumbar spinal fusion and THA have inferior QoL scores along with decreased hip-lumbar mobility ($\Delta LL + \Delta PFA$) compared to patients matched by age, sex, and BMI who underwent THA or lumbar fusion only. In addition, the hip-lumbar mobility was remarkably decreased in the group with leading to disability with toenail cutting and putting on/taking off of socks. Furthermore, multivariable logistic regression analysis showed that the decrease of the hip-lumbar mobility was also a factor affecting the ability to undertake activities such as toenail cutting and putting on/taking off of socks.

Factors contributing to inferior outcomes in patients who underwent both lumbar fusion and THA include subclinical impingement of the hip, lack of balance in the sagittal plane of the spine, and increased mechanical stress on the hip.^{22–24} These factors have been reported to be accompanied by complications such as infection, THA dislocation, and implant loosening and wear, leading to poor outcome and requiring revision surgery.^{25–27} The findings of this study suggest that the reason for the inferior QoL of patients who underwent both lumbar fusion and THA may be that lumbar spinal fusion reduces lumbar mobility and that patients fail to gain compensatory hip mobility, which reduces the overall hip-lumbar mobility and thus affects their QoL scores. This was particularly evident in activities such as toenail cutting and putting on/taking off of socks.

Prior studies have shown that the number of lumbar fusion levels impacts ADLs among postoperative lumbar fusion patients,^{5,28,29} especially patients with three or more fused levels who have increased limitation of ADLs compared to patients with one to two fused levels.⁵ We found that the S group with one to two fused levels experienced no noticeable difference in QoL scores on seven movement items, whereas the L group with three or more fused levels experienced a predominant decrease in most movement items compared to the Control T and F groups. Furthermore, consistent with our hypothesis, as the number of fixed levels increases, postoperative THA patients with low hip mobility compared to healthy volunteers had difficulty with the activities of cutting toenails and putting on/taking off of socks. This means that hip mobility needs to be greater than that of healthy volunteers in order to achieve a state of no disability when undertaking these activities. It has been reported that postoperative lumbar spinal fusion patients who also have osteoarthritis of the hip have a high rate of spinal reoperation.³⁰ This may be the result of failure to compensate for loss of lumbar mobility with increased hip mobility in daily living, and is consistent with our results. Therefore, clinicians should anticipate which patients might suffer from reduced hip-lumbar mobility and counteract disability in toenail cutting and putting on/taking off socks activities by suggesting appropriate assistive devices, such as a sock aid.

There are several limitations to this study. First, preoperative and postoperative evaluations, including lumbar spine-specific rating scales, were not available. It has been reported that patients who underwent both lumbar fusion and THA may have inferior preoperative outcomes due to overlapping lesions in the lumbar spine and hip.⁸ Future studies should evaluate preoperative and postoperative outcomes using lumbar spine and hip-specific disease rating scales, including the Oswestry Disability Index³¹ and JHEQ, to determine the relative weight of these aspects in patient QoL. Second, the order of lumbar fusion and THA was not standardized in this study. This may affect the mobility of the hip joint, and should be investigated in future studies. Third, there may be a selection bias in the analysis of, with or without disability, in toenail cutting and putting on/taking off of socks because hip-lumbar mobility alone was evaluated. Future studies should investigate covariates that affect toenail cutting and putting on/taking off socks. Although these limitations exist, the strength of this study is

that it provides objective values for hip-lumbar mobility and shows that it affects ADLs such as toenail cutting and putting on/taking off of socks.

Our study suggests that patients who underwent both lumbar fusion and THA had inferior QoL and decreased hip-lumbar mobility compared to patients who underwent THA or lumbar fusion only. Also, patients who underwent both three or more lumbar fusion and THA had even more decreased hip-lumbar mobility. Hip-lumbar mobility is a factor that influences activities, but mostly those requiring overall sagittal flexion. Clinicians need focus on hip-lumbar mobility and counteract disability by suggesting appropriate assistive devices.



Take home message

- In patients who underwent both total hip arthroplasty (THA) and lumbar fusion, lumbar fusion reduced lumbar mobility, and the failure to gain compensatory increased hip mobility resulted in an overall decrease in hip-lumbar mobility, which in turn affected quality of life.
- As the number of fused levels, postoperative THA patients with low hip mobility had difficulty with toenail cutting and putting on/taking off socks.
- Clinicians should anticipate which patients might suffer from reduced hip-lumbar mobility and counteract disability in nail clipping and socks putting on/taking off activities by suggesting appropriate assistive devices.

Supplementary material



Table showing additional radiological data.

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