Does the order of total hip replacement and lumbar spinal stenosis surgery influence patient-reported outcomes: An observational register study

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Abstract

Patients with degenerative hip and lumbar spine disorders requiring surgery in both locations is fairly common in clinical practice. We investigated if the order of total hip replacement (THR) and lumbar spinal stenosis surgery (LSSS) influences patient-reported outcomes (PROs). We used data from the Swedish Hip Arthroplasty Register (SHAR) and the Swedish Spine Register (Swespine), on patients operated with THR and LSSS in years 2002 to 2012. To increase the probability of having symptomatic disorders in both locations at the time of the first surgery, we only included patients with both LSSS and THR performed within 2 years. Linear and logistic regression analyses adjusted for age, sex, preoperative PROs, and time between surgeries were used to investigate the association between order of surgeries and the generic PRO measurements EQ-5D and EQ VAS. Eighty-four patients had THR prior to LSSS and 171 patients LSSS prior to THR. Linear regression showed that LSSS prior to THR was associated with higher EQ-5D index (β = 0.09, 95% confidence interval [CI] 0.03-0.16) and EQ VAS (β = 5.6, 95% CI 0.4-10.9) 1 year after the last surgery. Logistic regression showed that the odds ratio [OR] for not having any problems in the "pain" (OR = 3.0, 95% CI 1.5-6.3) and "anxiety/depression" (OR = 2.3, 95% CI 1.3-4.1) dimensions were higher for LSSS before THR. In our cohort, LSSS before THR was associated with better health-related quality of life outcomes compared to the reverse order. The results from our cohort can be helpful in a clinical situation where the physician gives advice to an individual patient when choosing the order of procedures. However, further studies are necessary in order to confirm these results in other cohorts. At present, standard of care remains that order of surgery should be individualized for each patient, with guidance from the operating surgeons.

KEYWORDS

hip osteoarthritis, hip-spine syndrome, lumbar spine surgery, patient-reported outcomes, spinal stenosis, total hip replacement
BACKGROUND

The hip-spine syndrome, first described by Ofierski et al in 1976, is the combination of degenerative disorders of the hip with osteoarthritis and lumbar spine with spinal stenosis. These disorders are both common in the elderly population and consequently, the combination of these degenerative diseases is common in clinical practice. Since these degenerative diseases also often cause similar symptoms, it is sometimes problematic to determine the main origin of the experienced pain. Since clinical examination rarely is conclusive, diagnostic tests such as intraarticular injection to the hip joint or spinal nerve root block with local anesthetics is often motivated in order to better determine whether pain derives from the lumbar spine, the hip, or both. There are several opinions and previous research suggests different approaches. Some favor starting with the hip because of the excellent results following total hip replacement (THR) while some studies take the improvement of low back pain following THR as an argument for starting with THR. Others have favored lumbar spinal stenosis surgery (LSSS) first because of the risk for contractions in spine nerve roots during the THR procedure that could result in nerve damage, such as drop foot following THR surgery.

LSSS with fusion and/or decompression and THR are both well-investigated interventions with successful outcomes for most of the treated patients. However, in the presence of degenerative diseases in both locations, there is limited knowledge on whether the order of surgery influences outcomes. To the best of our knowledge, there are no studies investigating outcomes following surgery in patients having undergone both THR and LSSS within a short period of time.

The aim of this study was to investigate differences in health-related quality of life 1 year following THR and LSSS in patients where both surgeries have been performed within two years.

METHODS

2.1 Sources of data

Data for this study were obtained from the Swedish Hip Arthroplasty Register (SHAR) and the Swedish Spine Register (Swespine) on patients operated with THR or LSSS during the years 2002 to 2012. The obtained data consisted of surgical, demographics, and patient-reported outcome measures (PROMs) data. The patients operated in both locations (hip and lumbar spine) due to degenerative diagnoses restricted to primary hip osteoarthritis and central spinal stenosis with and without olisthesis were selected.

SHAR started in 1979 and Swespine started in 1993. Intentionally, all surgical procedures of the spine and all hip replacement surgeries performed in Sweden are collected in the respective registers. The purposes of both registers are to monitor nationwide outcomes, stimulate improvement work, and conduct clinical research all with the overarching goal to improve patient outcomes. The collected data come both from publicly and privately funded hospitals. The completeness of registrations has been reported to be 98% for SHAR and 85% for Swespine. Both registries use the same identifier which is the unique personal identity number (PIN) given to all inhabitants in Sweden.

2.2 Outcome measures

For this study, we used the PROMs present in both registers, the EQ-5D-3L and the EQVAS. The EQ-5D-3L health status questionnaire is one of the most commonly used health-related quality of life (HRQoL) instruments. The EQ-5D-3L descriptive system includes five dimensions of health: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is covered by one question with three levels of severity: no problems, moderate problems, and severe problems. The descriptive system yields 243 possible health states. By applying weights given by a specific value set, each health state can be transformed into a single index that serves as an overall measure of HRQoL. The EQ VAS contains a visual analog scale addressing general health where 0 and 100 represent the worst and best possible health state. We used Dolan’s time-trade-off value set to calculate the EQ-5D index.

2.3 Patient selection

Initially, all THR and LSSS procedures performed during 2002 to 2012 from SHAR and Swespine were included. Prior to linking the registers, all secondary/contralateral procedures in each register were excluded. The registers were then linked based on the PIN and the patients occurring in both registers were identified. To increase homogeneity, we applied a set of predefined selection criteria to determine the final study population (Figure 1). We only included patients with central spinal stenosis. All other degenerative spinal diagnoses such as lateral spinal stenosis or lateral recess stenosis were excluded. The LSSS included decompression with or without fusion surgery from L1 to S1, both non- and instrumented fusions (Table 1). In order to increase the probability of having concurrent degenerative disease in the hip and spine at the time of the first surgery, we decided to only include patients operated with LSSS and THR within a 2-year timeframe.

2.4 Statistical methods

All raw demographic—surgical and PROMs—data following the selection were summarized as frequencies for categorical data, and means and associated standard deviations for continuous data. Group comparisons were conducted with $\chi^2$ test for categorical and $t$ test for continuous variables. The association between the order of surgery and outcomes 1 year after last surgery was investigated using linear regression for the EQ-5D index and EQ VAS scores. Simple and multiple main effects models were used for each outcome
in separate models. Logistic regression models were used to analyze individual EQ-5D dimensions after unification of response options 2 and 3 (moderate and severe problem). We present both unadjusted and adjusted regression outputs where the adjusted models included sex, age, preoperative PROM scores, and time between surgeries.

All pre- and postoperative EQ-5D-dimensions were dichotomized as either 0 if there was a moderate or severe problem (level 2 and 3), or 1 if no such problem occurred (level 1). We used logistic regression to model the probability of no postoperative problems for each dimension separately. We used simple and multiple main effect models with the same independent variables as described above for linear regression.

We also investigated how the health-related quality of life changed between the three measurement points; before the first surgery, before the second surgery, and 1 year after the second surgery.

In a subanalysis using logistic and linear regression models, we also investigated if fusion and decompression compared to decompression alone of the LSSS procedure had any influence on the outcomes. P values of <.05 were considered statistically significant.

Statistical analyses were performed in R (Foundation for Statistical Computing, Vienna, Austria).

2.5 | Ethical considerations

Ethical review approval was obtained from the Regional Ethical Review Board in Gothenburg, Sweden, entry number 236-13.
RESULTS

After exclusion of secondary procedures, there were 126,752 patients in SHAR and 25,394 patients in Swespine operated on from 2002 to 2012. Using the selection criteria presented in Figure 1, we identified 509 patients with surgery in both locations. Of these, 255 patients (50%) had both surgeries performed within 2 years. Eighty-four patients had THR performed prior to their LSSS and 171 patients had LSSS performed prior to THR. The groups reflected each other preoperatively in both demographics and common PROMs (Table 1). Mean time between surgeries differed significantly; time from LSSS to THR (312 days, SD 165) were shorter than time from THR to LSSS (460 days, SD 166). Of the patients with THR prior to LSSS 68% (n = 57) had leg pain over 1 year, for the group with LSSS prior to THR 77% (n = 132) had leg pain over 1 year. In patients having THR before LSSS 48% (n = 40) were decompressed and or fused on one level, and 51% (n = 43) on two or more levels. For the patients with LSSS prior to THR, 44% (n = 76) were decompressed.

| Table 1 | Demography and preoperative patient-reported outcome measures |
|---|---|
| | Hip first (n = 84) | Spine first (n = 171) | P |
| Age, mean (SD) | 70.46 (7.7) | 69.43 (7.3) | .30 |
| Sex, male (%) | 37 (44.0) | 71 (41.5) | .80 |
| Central spinal stenosis with olisthesis (%) | 22 (26.2) | 45 (26.3) | 1.00 |
| Time between surgeries, mean (SD) | 459.9 (166.1) | 311.7 (164.9) | <.001** |
| EQ-SD index, mean (SD) | 0.31 (0.30) | 0.30 (0.29) | .84 |
| Mobility (%) | | | |
| 1 | 0 (0.0) | 4 (0.3) | .38 |
| 2 | 84 (100.0) | 167 (97.7) | |
| 3 | 0 (0.0) | 0 (0.0) | |
| Self-care (%) | | | |
| 1 | 63 (75.0) | 135 (78.9) | .57 |
| 2 | 21 (25.0) | 35 (20.5) | |
| 3 | 0 (0.0) | 1 (0.6) | |
| Usual activities (%) | | | |
| 1 | 27 (32.1) | 45 (26.3) | .61 |
| 2 | 46 (54.8) | 100 (58.5) | |
| 3 | 11 (13.1) | 26 (15.2) | |
| Pain/discomfort (%) | | | |
| 1 | 1 (1.2) | 0 (0.0) | .35 |
| 2 | 32 (38.1) | 68 (39.8) | |
| 3 | 51 (60.7) | 103 (60.2) | |
| Anxiety/depression (%) | | | |
| 1 | 48 (57.1) | 93 (54.4) | .67 |
| 2 | 35 (41.7) | 73 (42.7) | |
| 3 | 1 (1.2) | 5 (2.9) | |
| EQ VAS, mean (SD) | 48.2 (23.6) | 48.6 (22.8) | .91 |
| Fusion (%) | 19 (22.6) | 42 (24.6) | .90 |

Note: Statistic tests were conducted with $\chi^2$ test for categorical variables and t test for continuous variables. Abbreviations; PLIF, posterior lumbar interbody fusion; SD, standard deviation; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog score. *P < .05 is equivalent to significance.
and or fused on one level, and 54% (n = 93) had surgery on two or more levels of the spine.

Postoperatively, there were statistically significant differences between the groups. Those who had LSSS prior to THR reported better outcomes 1 year after the last of the two procedures than did those who had THR prior to LSSS. The outcomes favored LSSS prior to THR regarding EQ-5D index, EQ VAS, and the separate dimensions of EQ-5D for "pain/discomfort" and "anxiety/depression" (all \( P < .05 \), Table 2).

Unadjusted and adjusted linear regression showed that LSSS prior to THR was associated with better outcomes in the EQ-5D index and EQ VAS (Table 3). Similarly, logistic regression showed that the proportion of no problems in "pain/discomfort" and "anxiety/depression" (Table 4) was higher for patients operated with LSSS before THR.

Regardless of which procedure came first, there were no significant differences in health-related quality of life changes from prior to first compared with prior to the second procedure for neither EQ-5D index nor EQ VAS (all \( P > .05 \), Table 5). Significant improvement occurred from the level before the second surgery to the 1-year follow-up of the last procedure (all \( P < .0001 \), Table 5, Figure 2).

The subanalysis of LSSS comparing fusion vs decompression alone, showed no association for the EQ-5D index, EQ VAS, or most of the EQ-5D dimensions. Fusion was superior to compression alone for self-care (OR = 3.0, 95% CI: 1.1-8.2, \( P = .03 \), Table 6).

### 4 | DISCUSSION

#### 4.1 | Significance of findings in relation to previous research

Both decompression surgery for LSSS and total hip arthroplasty (THR) for hip arthrosis are very common among elderly, and it is not uncommon that the two disorders coexist. Several studies report outcomes following LSSS or THR procedures, and the relationship with coexistent degenerative spine and hip disorders. There are consistent findings in the literature regarding the negative influence of hip surgery on quality of life measures.

### TABLE 2 One-year postoperative outcome measures following last surgery

| Mobility (%) | First | Second | \( P \) |
|---------------|-------|--------|------|
| 1             | 24 (28.6) | 65 (38.0) | .18 |
| 2             | 60 (71.4) | 106 (62.0) | |
| 3             | 0 (0.0) | 0 (0.0) | |

| Self-care (%) | First | Second | \( P \) |
|---------------|-------|--------|------|
| 1             | 73 (86.9) | 156 (91.2) | .26 |
| 2             | 10 (11.9) | 15 (8.8) | |
| 3             | 1 (1.2) | 0 (0.0) | |

| Usual activities (%) | First | Second | \( P \) |
|----------------------|-------|--------|------|
| 1                    | 47 (56.0) | 110 (64.3) | .43 |
| 2                    | 34 (40.5) | 56 (32.7) | |
| 3                    | 3 (3.6) | 5 (2.9) | |

| Pain/discomfort (%) | First | Second | \( P \) |
|---------------------|-------|--------|------|
| 1                   | 12 (14.3) | 57 (33.3) | .004* |
| 2                   | 60 (71.4) | 100 (58.5) | |
| 3                   | 12 (14.3) | 14 (8.2) | |

| Anxiety/depression (%) | First | Second | \( P \) |
|------------------------|-------|--------|------|
| 1                      | 51 (60.7) | 129 (75.4) | .05* |
| 2                      | 32 (38.1) | 41 (24.0) | |
| 3                      | 1 (1.2) | 1 (0.6) | |

| EQ VAS, mean (SD) | First | Second | \( P \) |
|-------------------|-------|--------|------|
| 1                 | 65.56 (20.96) | 71.15 (20.69) | .04* |

Note: Statistical tests were conducted with the \( \chi^2 \) test for categorical variables and \( t \) test for continuous variables.

Abbreviations: ADL, activity of daily living; SD, standard deviation; VAS, visual analog scale.

*\( P < .05 \) is equivalent to significance.

### TABLE 3 The association between order of surgery and EQ-5D index and EQ VAS 1 year after last surgery (linear regression, with THR prior to LSSS set as reference)

| EQ-5D Index | Crude 95% CI | Adjusted 95% CI |
|-------------|--------------|-----------------|
| 0.09*       | (0.02; 0.16) | (0.03; 0.16) |

| EQ VAS | Crude 95% CI | Adjusted 95% CI |
|--------|--------------|-----------------|
| 5.6*   | (0.14; 11.1) | (0.4; 10.9) |

Note: Preoperative PROM score, age, sex, and time between surgeries were used as independent variables in the adjusted analysis. The table presents linear regression coefficients and associated 95% confidence intervals (CIs).

Abbreviations: LSSS, lumbar spinal stenosis surgery; PROM, patient-reported outcome measure; THR, total hip replacement; VAS, visual analog scale.

*\( P < 0.05 \) is equivalent to significance.

### TABLE 4 The association between order of surgery and each EQ-5D dimension 1 year after last surgery (logistic regression, with THR prior to LSSS set as reference)

| Mobility | Crude 95% CI | Adjusted 95% CI |
|----------|--------------|-----------------|
| 1.53     | (0.88; 2.73) | (0.86; 2.72) |

| Self-care | Crude 95% CI | Adjusted 95% CI |
|-----------|--------------|-----------------|
| 1.57      | (0.67; 3.56) | (0.35; 2.59) |

| Usual activities | Crude 95% CI | Adjusted 95% CI |
|------------------|--------------|-----------------|
| 1.42             | (0.83; 2.42) | (0.88; 2.62) |

| Pain | Crude 95% CI | Adjusted 95% CI |
|------|--------------|-----------------|
| 3.00* | (1.55; 6.22) | (1.54; 6.29) |

| Anxiety/depression | Crude 95% CI | Adjusted 95% CI |
|--------------------|--------------|-----------------|
| 1.99*              | (1.13; 3.48) | (1.25; 4.14) |

Note: Preoperative PROM score, age, sex, and time between surgeries were used as independent variables in the adjusted analysis. The table presents odds ratios from logistic regression and associated 95% confidence intervals (CIs).

Abbreviations: LSSS, lumbar spinal stenosis surgery; PROM, patient-reported outcome measure; THR, total hip replacement.

*\( P < 0.05 \) is equivalent to significance.
Studies have shown that THR often increases neurogenic claudication symptoms in patients with lumbar spinal stenosis (LSSS). In addition, THR often increases the mobility of patients with lumbar spine disorders have less improvement following THR. Previous research has also shown a negative effect on the outcomes of LSSS in patients with preoperative walking impairment and coexistent hip osteoarthritis. However, there are, to our knowledge, no reports investigating and comparing the outcome following both LSSS and THR in patients with both procedures performed within a short period of time (2 years).

Interestingly, we identified almost twice as many patients who had LSSS before THR within 2 years than the opposite order. This relationship is also apparent in a longer investigated period. There are several possible explanations for this. One may be that THR not only improves hip-related pain but also reduces back pain, a finding presented in several studies. The reduction of pain in other locations than the hip is probably due to the complex pain referral in hip osteoarthritis. In addition, THR often increases patients’ hip range of motion, and with increased mobility, the ability to accomplish controlled exercises may improve and the stress on narrow spinal segments may decrease. This could potentially reduce pain from spinal stenosis and may postpone the need for the following LSSS. Another possibility is that patients with neurogenic claudication from central spinal stenosis simply cannot walk distances long enough to elicit symptoms from their hip osteoarthritis. Therefore, the relief of the central spinal stenosis following LSSS unMASKS a latent hip osteoarthritis problem when the patient attempts longer ambulation, and presents the need for the following THR. Conversely, a patient with fulminant hip arthrosis probably cannot walk far enough to elicit neurogenic claudication symptoms and would probably have their hip done first.

One important possible confounding factor is that the availability in Sweden for THR is higher than for LSSS. Therefore, THR will most often be provided after a shorter waiting time than LSSS. Another potential confounding factor is the possibility for an incorrect diagnosis causing the patient’s main symptom at the time of the index procedure, be it LSSS or THR. However, with the thorough clinical assessment in several steps, an examination by general practitioner and specialists prior to decision(s) about surgery, this is not believed to explain the results from the present study.

This study implies some advantages of performing surgery for LSSS before THR if both surgeries are indicated. However, the fact that it is twice as common with THR following LSSS than the opposite reflects that this is not what is usually performed in clinical practice. Our study suggests that regardless of which procedure was performed first, the improvement mainly occurred from the level of health-related quality of life before the second procedure to 1-year after this second procedure. This implies that patients suffering from both lumbar spinal stenosis and hip osteoarthritis are in need for surgery for both disorders in order to improve their overall HRQoL. Another possible explanation for improvement mainly after the

**TABLE 5** Differences in PROMs between interventions following first (only THR or LSSS) and second (both THR and LSSS) procedures

| Period | First procedure | Difference | P     |
|--------|----------------|------------|-------|
| 1      | EQ-5D index    | Hip        | 0.07  | .07  |
|        |                | Spine      | −0.02 | .4   |
| 2      | EQ-5D index    | Hip        | 0.27  | .0001*|
|        |                | Spine      | 0.41  | .0001*|
| 1      | EQ VAS         | Hip        | 2.1   | .5   |
|        |                | Spine      | 2.3   | .2   |
| 2      | EQ VAS         | Hip        | 15.9  | .0001*|
|        |                | Spine      | 20.9  | .0001*|

*P < .05 is equivalent to statistical significance.

**Fig. 2** Health-related quality of life before first, before second, and 1 year after second procedure. Preop 1, preoperative first procedure; Preop 2, preoperative second procedure; Postop 2, postoperative second procedure [Color figure can be viewed at wileyonlinelibrary.com]

**TABLE 6** Regression coefficients and odds ratios after the second surgery, for fusion vs decompression alone in patients with LSSS

|                | Fusion       | P     |
|----------------|--------------|-------|
| EQ-5D index    | 1.3 (0.5; 2.9) | .6   |
| EQ VAS         | −0.8 (−6.9; 5.3) | .8   |
| Mobility       | 1.2 (0.6; 2.3) | .6   |
| Self-care      | 0.3 (0.1; 0.9) | .03* |
| Usual activities| 0.9 (0.5; 1.6) | .6   |
| Pain/discomfort| 1.3 (0.7; 2.6) | .4   |
| Anxiety/depression | 1.5 (0.7; 3.1) | .3   |

Abbreviations: LSSS, lumbar spinal stenosis surgery; VAS, visual analog scale.

Regression coefficients and associated 95% confidence intervals using linear regression analysis for the EQ-5D index and EQ VAS.

Regression coefficients and associated 95% confidence intervals using odds ratios for no problem in each individual EQ dimension.

*P < .05 is equivalent to statistical significance.
second procedure could be that only patients with disorders in both locations and poor result after the first procedure received a second surgery within a 2-year timeframe. So, despite earlier reports that patients with degenerative disease in both the hip and lumbar back have a worse outcome following surgery, these patients should not, generally speaking, be excluded from surgery in both locations. However, in most cases, it is probably not possible to establish a general rule on where to start surgery in patients with "hip-spine syndrome." For patients with symptomatic degenerative disease in both locations, it is important to explain that regardless of surgical order, the expected outcome may not be as good as for patients with isolated hip or spine disease, and the risk of need for further surgery in the other location should be discussed. Reasonably, the decision on what order to start with needs to balance several important factors such as which disorder appears to be most troublesome, based on clinical and radiological findings, physical function, and comorbidity. The way forward is probably to create decision-making tools providing individualized information on risks and benefits to guide the surgeon and the patient in the shared decision-making process of which location to commence. The subspecialization with few specialists performing both arthroplasties and spine surgery further encourage collaboration and guidelines to improve patient care for these patients.

We believe our work contributes to the knowledge about the sometimes complicated treatment and assessment of patients with "hip-spine syndrome." Importantly, the combination of spine and hip problems prior to LSSS or THR surgery predisposes worse patient-reported outcomes regardless of the order of procedures.

4.2 | Strengths and limitations

The data used come from two well-established and thoroughly validated national quality registers. Thus, the results reflect the general orthopedic practice in Sweden, which limits performance bias and increases generalizability. A large number of patients available to the study groups is also a strength to the study. The thorough selection procedure in this study contributes to reducing confounding bias and heterogeneity.

The preoperative PROMs are in these two groups close regardless of first procedure (Table 1). In two earlier publications, we have investigated the outcome following both THR with an earlier LSSS, and LSSS with an earlier THR performed and compared with patients with only THR or LSSS performed, respectively. Those studies demonstrated lower preoperative PROM scores but higher postoperative PROM scores for THR compared to LSSS. Also, if compared with pre- and postoperative EQSD-index and EQ VAS scores for both THR and LSSS, the patients in our cohorts have worse preoperative PROMs, and did not achieve as high outcomes as those with only one of the procedures performed. This implies that the groups we investigated in this study had a higher possibility of concomitant disease prior to the first procedure.

This study have several limitations. Importantly, the assumption that patients had symptomatic degenerative diseases in both locations prior to surgery based on the short time between surgeries could be questioned. We acknowledge the lack of information on possible degenerative diseases that are treated nonsurgically in the hip or spine. Therefore, in patients with only one of the procedures performed, we do not know if there was a possible symptomatic degenerative disease in the other location, respectively, that have not had a need for further surgery. It is also a limitation that there were no adjustments for influence of other possible musculoskeletal conditions or the presence of joint replacements in other locations.

It could also be expected that prolonged time to LSSS may have influenced the postoperative result to a higher extent than for THR. There was a large number of patients excluded due to missing PROMs in both registers, this is because a large number of patients were never invited to participate in the early years of the study period.

As we only had access to data regarding patients operated up to 2012, the results may not reflect contemporary arthroplasty and spinal surgery care. Another limiting factor is the lack of analysis regarding the extent of surgery in terms of lumbar segments involved and sacral involvement. Finally, the study is limited to the data existing in the registries; clinical information such as motor deficit, bilateral vs unilateral neurogenic claudication, radiographic outcomes, and functional test scores are not available.

We only investigated outcome measures used in the two registers, which limits the richness of the analyses. Since SHAR collects data on hip pain, while Swespine collects data on back and leg pain, we were restricted to measure pain as reported by the pain/discomfort dimension of the quality of life measure; EQ-5D. Although both registries collect a satisfaction item, the wording and response options differ, which makes it inappropriate to combine these in the same analysis.

5 | CONCLUSION

In our cohort with patients who underwent LSSS and THR within a 2-year time period, LSSS prior to THR was associated with better HRQoL improvement compared to those who had surgery in the reverse order. Regardless of the order of the two procedures, the improvement predominantly occurred from the patient-reported level before second procedure to the level reported 1 year after this second surgery. Thus, patients with degenerative disease in both the hip and lumbar spine were in need for surgery in both locations in order to improve their HRQoL. Because of the nature of this observational study, factors affecting surgical decision-making are not clear, and there are no data available on the outcomes of LSSS and THR performed many years apart from each other. Considering the relatively large influence of order of surgery on PROMs in this study cohort, further research in well-designed prospective studies is warranted. The results from our cohort can be helpful in a clinical situation where the physician gives advice to an individual patient when choosing the order of procedures. However, at present, standard of care remains that order of surgery should be individualized for each patient, with guidance from the operating surgeons.
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CONFLICT OF INTERESTS
The authors declare that there are no conflict of interests.

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## APPENDIX

See Table A1, A2, A3

### TABLE A1  Pain VAS back preoperatively LSSS

| Pain VAS spine n = 255 | n | %  |
|------------------------|---|-----|
| 0-10                   | 20| 8   |
| 11-20                  | 12| 5   |
| 21-30                  | 22| 9   |
| 31-40                  | 13| 5   |
| 41-50                  | 36| 14  |
| 51-60                  | 21| 8   |
| 61-70                  | 36| 14  |
| 71-80                  | 43| 17  |
| 81-90                  | 26| 10  |
| 91-100                 | 10| 4   |
| NA                     | 16| 6   |

**Abbreviations:** LSSS, lumbar spinal stenosis surgery; NA, no answer; VAS, visual analog scale.

### TABLE A2  Pain VAS leg preoperatively LSSS

| Pain VAS leg n = 255 | n | %  |
|----------------------|---|-----|
| 0-10                 | 11| 4   |
| 11-20                | 7 | 3   |
| 21-30                | 9 | 4   |
| 31-40                | 11| 4   |
| 41-50                | 25| 10  |
| 51-60                | 19| 7   |
| 61-70                | 53| 21  |
| 71-80                | 44| 17  |
| 81-90                | 39| 15  |
| 91-100               | 25| 10  |
| NA                   | 12| 5   |

**Abbreviations:** LSSS, lumbar spinal stenosis surgery; NA, no answer; VAS, visual analog scale.

### TABLE A3  Pain VAS hip preoperatively THR

| Pain VAS hip n = 255 | n | %  |
|----------------------|---|-----|
| 0-10                 | 1 | 0   |
| 21-30                | 6 | 2   |
| 31-40                | 5 | 2   |
| 41-50                | 29| 11  |
| 51-60                | 44| 17  |
| 61-70                | 100| 39 |
| 71-80                | 55| 22  |
| 81-90                | 15| 6   |

**Abbreviations:** LSSS, lumbar spinal stenosis surgery; THR, total hip replacement; VAS, visual analog scale.