

■ HIP

Dislocation of a primary total hip arthroplasty is more common in patients with a lumbar spinal fusion

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Aims

Lumbar fusion is known to reduce the variation in pelvic tilt between standing and sitting. A flexible lumbo-pelvic unit increases the stability of total hip arthroplasty (THA) when seated by increasing anterior clearance and acetabular anteversion, thereby preventing impingement of the prosthesis. Lumbar fusion may eliminate this protective pelvic movement. The effect of lumbar fusion on the stability of total hip arthroplasty has not previously been investigated.

Patients and Methods

The Medicare database was searched for patients who had undergone THA and spinal fusion between 2005 and 2012. PearlDiver software was used to query the database by the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedural code for primary THA and lumbar spinal fusion. Patients who had undergone both lumbar fusion and THA were then divided into three groups: 1 to 2 levels, 3 to 7 levels and 8+ levels of fusion. The rate of dislocation in each group was established using ICD-9-CM codes. Patients who underwent THA without spinal fusion were used as a control group. Statistical significant difference between groups was tested using the chi-squared test, and significance set at $p < 0.05$.

Results

At one-year follow-up, 14 747 patients were found to have had a THA after lumbar spinal fusion (12 079 1 to 2 levels, 2594 3 to 7 levels, 74 8+ levels). The control group consisted of 839 004 patients. The dislocation rate in the control group was 1.55%. A higher rate of dislocation was found in patients with a spinal fusion of 1 to 2 levels (2.96%, $p < 0.0001$) and 3 to 7 levels (4.12%, $p < 0.0001$). Patients with 3 to 7 levels of fusion had a higher rate of dislocation than patients with 1 to 2 levels of fusion (odds ratio (OR) = 1.60, $p < 0.0001$). When groups were matched for age and gender to the unfused cohort, patients with 1 to 2 levels of fusion had an OR of 1.93 (95% confidence interval (CI) 1.42 to 2.32, $p < 0.001$), and those with 3 to 7 levels of fusion an OR of 2.77 (CI 2.04 to 4.80, $p < 0.001$) for dislocation.

Conclusion

Patients with a previous history of lumbar spinal fusion have a significantly higher rate of dislocation of their THA than age- and gender-matched patients without a lumbar spinal fusion.

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Instability remains one of the most common reasons for early revision of a total hip arthroplasty (THA).¹ While the cause of instability is multifactorial, positioning of the acetabular and femoral components play an important role. Lewinnek et al² described a “safe zone” for positioning of the acetabular component in between $40^\circ \pm 10^\circ$ of abduction and $15^\circ \pm 10^\circ$ of anteversion. However, in their study they used a standardised radiological technique to eliminate pelvic tilt by positioning the anterior superior iliac spines and pubic symphysis level

parallel to the radiograph film, essentially in 0° of tilt in the anterior pelvic plane.

Recently, much attention has been focused on the change in position of the acetabular component with changes in pelvic tilt, as has the effect that postural changes have on lumbo-pelvic alignment.³⁻⁷ Lembeck et al⁸ found that a change in the anterior pelvic plane by 1° changes acetabular anteversion by 0.7° . Kanawade et al³ recently reported that a pelvis with normal mobility is able to retrovert (tilt posteriorly) by between 20° and 35° when

moving from standing to sitting. They also found that a “stiff” pelvis has statistically less posterior pelvic tilt when moving from standing to sitting than a normal or hypermobile pelvis. The ‘mobility’ of the pelvis between standing and sitting is a function of the change in lumbar lordosis or lumbosacral movement.^{9,10}

This study sought to expand our understanding of the stiff spine, particularly the surgically fused lumbar spine, and consider its implications for the stability of THA. By reviewing a large database, we sought to answer the following questions. First, do patients with a fused spine have a higher rate of dislocation after THA than patients who have not undergone spinal fusion? Secondly, does the number of fused levels affect the rate of dislocation after THA? Our hypothesis was that lumbar spinal fusion leads to an increased rate of hip instability after THA.

Materials and Methods

This study is a retrospective analysis of prospectively collected billing data from the Center for Medicare Service between 2005 and 2012, across all Medicare service providers in the United States. The data includes all Medicare inpatient, outpatient and emergency medical treatment. This data is stored and accessed through the PearlDiver Patient Records Database (PearlDiver Inc., Fort Wayne, Indiana), a for-fee service database. A waiver of institutional review board (IRB) approval was received for this study as all data had been previously acquired and de-identified.

The Medicare database was searched for all patients who had undergone primary THA and/or primary lumbar spinal fusion. First, patients who underwent lumbar fusion surgery were identified by the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)¹¹ procedural codes 81.06 (lumbar or lumbosacral fusion of anterior column by anterior technique), 81.07 (lumbar or lumbosacral fusion of posterior column) and 81.08 (lumbar or lumbosacral fusion of anterior and posterior column by posterior technique). This cohort of patients was then divided into three groups: 1 to 2 levels of spinal fusion (ICD-9-CM: 81.62), 3 to 7 levels (81.63) and 8+ levels (81.64). To ensure that these were all primary procedures, each group was narrowed to include only those patients without evidence of revision fusion surgery of the thoracolumbar spine (ICD-9-CM: 81.3x; Current Procedural Terminology (CPT)¹² code: 22849 to 22855) coded on the same day, or before the day of the index procedure.

After creating these three cohorts, each individual group was further narrowed to select patients who were subsequently treated by THA (ICD-9-CM: 81.51). All patients with a revision/conversion THA (ICD-9-CM: 81.53; CPT: 27132, 27134, 27137, 27138) were excluded. Consequently, every patient in this study had a primary THA undertaken after a primary spinal fusion.

The full set of primary THAs was then narrowed to create a control population who had not undergone spinal fusion (ICD-9-CM: 81.0x, 81.3x; CPT: 22532 to 22855).

There were, therefore, four cohorts for further analysis: 1 to 2-level lumbar fusion with subsequent THA (THA-Short Fusion; THA-SF, n = 12 079); 3 to 7-level lumbar fusion with subsequent THA (THA-Long Fusion; THA-LF, n = 2 594); 8+ level lumbar fusion with subsequent THA (THA-8+, n = 74); and primary THA without the ICD-9-CM code for previous spine fusion (THA-only, n = 839 004).

The one-year rate of dislocation for each study group was then determined. Patient records were analysed for the presence of ICD-9-CM codes 835.0, 835.00, 835.01, 835.02, 835.03 and 996.42 during the year after THA. All relevant ICD-9-CM codes are shown in Table I. To adjust for age and gender, matched cohorts were created from the 1 to 2-level lumbar fusion and primary THA groups without spinal fusion, which contained the same proportion of patients with a given age (stratified by < 65 years, 65 years to 69 years, 70 years to 74 years, 75 years to 79 years, 80 years to 84 years, and ≥ 85 years old) and gender combination as the 3 to 7-level lumbar fusion cohort. Dislocation rates within each of these three matched cohorts were then compared. Coding accuracy for both hip and spine procedures and diagnoses were verified independently by the institutional billing department at New York University Langone Medical Center.

Statistical analysis. This was carried out using SPSS software (version 20.0, IBM, Armonk, New York). Dislocation rates were compared using Pearson chi-squared analysis. Odds ratios (OR) and 95% confidence intervals (CI) were determined when comparing matched cohorts. Statistical significance was set at $p < 0.05$ for all comparisons.

Results

The Medicare database query between 2005 and 2012 showed that 434 387 patients had undergone lumbar or lumbosacral fusion. A total of 364 071 patients underwent 1 to 2-level fusions, 67 779 underwent 3 to 7-level fusions and 2 537 underwent 8+ level fusions. In the same time period 889 146 patients underwent primary THA.

When THA and lumbar fusion codes were combined, 12 079 patients had undergone 1- to 2-level fusion followed by THA (THA-SF), 2594 patients 3 to 7-level fusion followed by THA (THA-LF) and 74 patients 8+ level fusion followed by THA. A total of 839 004 patients had undergone THA without any previous lumbar fusion during the full eight-year study period (THA-only). The three study groups had significant differences in age and gender (Table II).

The dislocation rate increased significantly with increasing number of spinal levels fused (Table III). Patients in THA-SF had a 2.96% dislocation rate (357/12079, $p < 0.0001$ versus THA-only). THA-SF had a component revision rate of 0.35% (43/12079; OR 1.69, $p < 0.001$ compared with THA-only). THA-LF had a dislocation rate of 4.12% (107/2594, $p < 0.0001$ versus THA-only). The dislocation rate in the THA-only was 1.55% (12 982/839 004) and there was a revision rate of 0.21% (1691/800

Table I. International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) and Current Procedural Terminology (CPT) codes for inclusion and exclusion criteria for patients with lumbar spinal fusion and total hip arthroplasty (THA)

	Description
Inclusion criteria	
ICD-9-CM 81.06	Lumbar or lumbosacral fusion of the anterior column by anterior technique
ICD-9-CM 81.07	Lumbar and lumbosacral fusion of the posterior column by posterior technique
ICD-9-CM 81.08	Lumbar or lumbosacral fusion of anterior and posterior column by posterior technique
ICD-9-CM 81.62	Fusion of 2 to 3 vertebrae (1 to 2 levels)
ICD-9-CM 81.63	Fusion of 4 to 8 vertebrae (3 to 7 levels)
ICD-9-CM 81.64	Fusion of 9 or more vertebrae (8+ levels)
ICD-9-CM 81.51	THA
Exclusion criteria	
For THA and lumbar spinal fusion cohorts	
ICD-9 81.3x	Revision spine fusion surgery
CPT 22849	Reinsertion of spinal fixation device
CPT 22850	Removal of posterior non-segmental instrumentation (e.g. Harrington rod)
CPT 22852	Removal of posterior segmental instrumentation
CPT 22855	Removal of anterior instrumentation
Additional exclusions for THA-only cohort	
CPT 22532-22534	Arthrodesis, lateral extracavitary approach
CPT 22551, 22552, 22554, 22556, 22558, 22585	Arthrodesis, anterior interbody technique
CPT 22590, 22595, 22600, 22610, 22630, 22632, 22800, 22802, 22804	Arthrodesis, posterior technique (interbody, for deformity, etc.)
CPT 22808, 22810, 22812	Arthrodesis, anterior, for spinal deformity
CPT 22840-22444	Posterior instrumentation
CPT 22845-22847	Anterior instrumentation
CPT 22848	Pelvic fixation
CPT 22849-22855	(as above)
CPT 27132	Conversion of previous hip surgery to THA
CPT 27134	Revision of THA; both components
CPT 27137	Revision of THA; acetabular component only
CPT 27138	Revision of THA; femoral component only
ICD-9 81.0x	Primary spine fusion
ICD-9 81.3x	(as above)
81.53	Revision of hip arthroplasty
ICD-9-CM diagnosis codes	
835.0	Closed dislocation of hip
835.00	Closed dislocation of hip, unspecified site
835.01	Closed posterior dislocation of hip
835.02	Closed obturator dislocation of hip
835.03	Other closed anterior dislocation of hip
996.42	Dislocation of prosthetic joint

094). THA-LF had a significantly higher dislocation rate than THA-SF ($p = 0.002$). The THA-8+ group had ≤ 11 dislocations and as a result cannot be reported as per the Data Use Agreement between PearlDiver and Center for Medicare and Medicaid Services Data Use Agreement.¹³ The THA-8+ group was therefore excluded from further analysis. Similarly, the rates of dislocation requiring open reduction for the THA-SF, THA-LF and THA-8+ groups, and THA component revision rate for THA-LF and THA-8+ groups could not be reported due to the presence of < 11 events in each category.

Age- and gender-adjusted cohort analysis revealed a significantly different dislocation rate between each of the groups (Table IV). THA-LF remained the group with the highest risk of dislocation compared with THA-SF (OR 1.60, 95% CI 1.24 to 2.07, $p = 0.0003$) and THA-only (OR 2.77, 95% CI 2.28 to 3.36, $p < 0.0001$).

Discussion

The flexibility and change in alignment of the spine plays an important role in the biomechanics of the hip, and has several implications for the performance and function of a THA.^{6,14} A fused spine stiffens the lumbar segments and directly affects mobility of the pelvis. A longer spinal fusion may theoretically further reduce movement of the lumbo-pelvic segment.

Our study asked the following questions: is the dislocation rate of a THA higher after lumbar spinal fusion, and does the number of levels fused affect the rate of dislocation?

We found that patients who had undergone spinal fusion had a higher rate of dislocation after primary THA than those who had not: patients with a 1 to 2-level lumbar spinal fusion had a higher rate of component revision. Similarly, we found that the more spinal levels fused, the higher

Table II. Demographics of patients undergoing total hip arthroplasty (THA) and 1 to 2-level lumbar fusion (THA-Short Fusion, THA-SF), 3 to 7-level lumbar fusion (THA-Long Fusion, THA-LF), and no lumbar fusion (THA-only)

	THA-SF, n (%) (n = 12 079)	THA-LF, n (%) (n = 2594)	THA-only, n (%) (n = 839 004)	THA-SF vs THA-LF (chi-squared p-value)	THA-LF vs THA-only (chi-squared p-value)	THA-SF vs THA-only (chi-squared p-value)
Age (yrs)						
< 65	1252 (10.4)	221 (8.5)	82083 (9.8)	0.005	0.03	0.03
65 to 69	2493 (20.6)	537 (20.7)	199029 (23.7)	0.94	0.0003	< 0.0001
70 to 74	3418 (28.3)	706 (27.2)	181703 (21.7)	0.27	< 0.0001	< 0.0001
75 to 79	2733 (22.6)	644 (24.8)	171556 (20.4)	0.016	< 0.0001	< 0.0001
80 to 84	1635 (13.5)	357 (13.8)	127672 (15.2)	0.76	0.04	< 0.0001
85+	548 (4.5)	129 (5.0)	76961 (9.2)	0.34	< 0.0001	< 0.0001
Gender (female)	7947 (65.8)	1691 (65.2)	515331 (61.4)	0.56	< 0.0001	< 0.0001

Bold values are significant

Table III. Incidence and dislocation rates of total hip arthroplasty (THA) patients between lumbar fusion groups

Cohorts	n	Dislocations within 1 yr	Dislocation rate (%)	vs THA-LF (chi-squared p-value)	vs THA-only (chi-squared p-value)
THA-SF	12079	357	2.96	0.002	< 0.0001
THA-LF	2594	107	4.12		< 0.0001
THA-only	839004	12982	1.55		

Bold values are significant

THA-SF, THA-Short Fusion; THA-LF, THA-Long Fusion

Table IV. Total hip arthroplasty (THA) dislocation rates between age- and gender-matched cohort of spinal fusion groups

Comparison	Odds ratio	95% confidence interval	p-value
THA-LF vs THA-SF	1.60	1.24 to 2.07	0.0003
THA-LF vs THA-only	2.77	2.28 to 3.36	< 0.0001
THA-SF vs THA-only	1.93	1.73 to 2.15	< 0.0001

Bold values are significant

THA-SF, THA-Short Fusion; THA-LF, THA-Long Fusion

the dislocation rate. Due to limitations in sample size we were unable to establish whether the rate of component revision was further increased with ≥ 3 -level lumbar fusion.

Impingement is a common cause for dislocation after THA due to a variety of surgeon-dependent, patient-dependent, and device-dependent factors.¹⁵

When adding the dynamic component of lumbo-pelvic movement between a standing and sitting position, the pelvis tilts posteriorly by a mean of 22° to 28°. ^{3,16} This increase in posterior pelvic tilt creates more acetabular anteversion (Fig. 1), thereby clearing the anterior lip of the component from impingement by the femoral stem, and protecting against posterior hip dislocation.¹⁵ Lumbar fusion is known to decrease the variation in pelvic tilt between standing and sitting⁴ (Fig. 2). The ability of the pelvis/hip to protect itself from prosthetic impingement, and ultimately dislocation, is therefore decreased. Long segment spinal fusions to the pelvis may result in a reduction in pelvic tilt in sitting (Fig. 3). This may explain our findings that patients with a lumbar spinal fusion have a higher rate of dislocation and that the rate of dislocation increases with the number of levels fused.

Patients with a sagittal spinal deformity may have increased pelvic tilt and functional acetabular malalignment, particularly excessive anteversion.^{6,17} An extreme example is ankylosing spondylitis, which causes sagittal malalignment and may behave in a similar manner to the spinal fusion group. This is likely to be why this group of patients has an increased risk of anterior dislocation after THA.¹⁸⁻²⁰ Although the effects of sagittal spinal deformity on postural pelvic tilt change remain undescribed, it is most likely that these patients have less variation in lumbosacral movement between sitting and standing, thereby further narrowing the safe range of anteversion in which the acetabular component may be implanted.

Several studies have examined the interplay between spinal deformity and acetabular orientation. Phan et al¹⁴ provided a systematic review of the literature, and made treatment and pre-operative imaging recommendations for patients with a history of spinal surgery, postural imbalance, or arthritic changes at the lumbosacral junction. Buckland et al⁶ found that changes in spinal alignment after the correction of spinal deformity affected the position of the acetabular component. Tang et al²¹ described a method

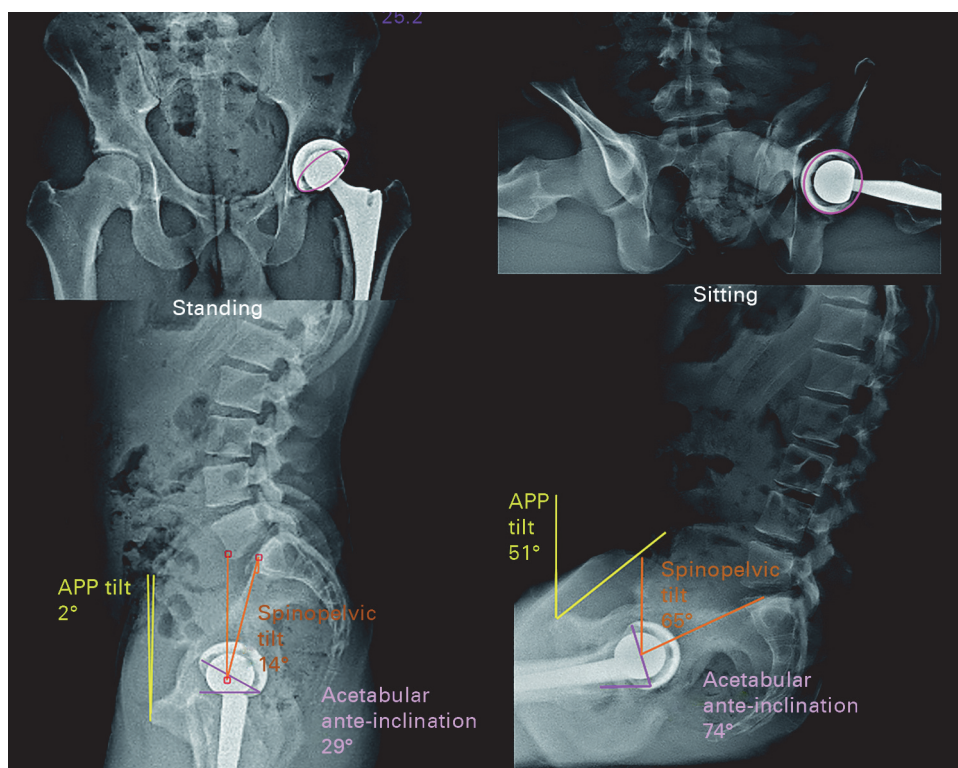


Fig. 1

Standing (left) and sitting (right) radiographs of a patient with total hip arthroplasty *in situ*. Note the increase in pelvic tilt and acetabular anteversion in sitting (APP, anterior pelvic plane).

of compensating for sagittal pelvic malrotation by changing the position of the acetabular component and noted that this would result in instability if malalignment exceeded 20°.

This study has some limitations. The data used are from a large database of Medicare patients. There are limitations in the data inherent to any retrospective billing database review. This database provides a cross-sectional snapshot of the full set of Medicare records between 2005 and 2012 searched by ICD-9-CM codes. It is possible that a patient who underwent a lumbar spinal fusion before 2005 could be included in the control group, because the procedure itself was not performed in the study window between 2005 and 2012. However, if these patients were included, our results suggest that it would artificially increase in dislocation rate in the control group and understate the true increase in dislocation rate in THA as a result of previous spinal fusion, thereby strengthening our conclusion. We did not use the 'status post fusion' ICD-9-CM code (V45.4) as it is not specific to spinal fusion, another limitation in ICD-9-CM coding.

The dislocation rate in the control group is consistent with that in the existing literature.²² Instability occurs in

approximately 1% of THAs in the first month, 1.9% in the first year, and thereafter increases at a linear rate to a cumulative risk of 7% at 20 years.²²

As this was a database review, we did not have access to radiographs of either the spine or the pelvis. We have no way of knowing whether the spine was fused to the sacrum or pelvis since ICD-9-CM coding does not allow this to be queried. However, it is logical that a larger proportion of patients in the 3 to 7-level fusion group would have undergone fusion to the sacrum compared with those with a 1 to 2-level fusion, and probably accounts for the higher dislocation rate seen in the 3 to 7-level fusion patients. This is an important piece of information as the core of the hip spine relationship is through the pelvis/sacrum, but unfortunately, we have no way of determining this from this dataset. Furthermore, we were unable to determine whether performing spinal fusion before or after THA would result in a lower dislocation rate. Owing to limitations in national databases, information is lacking regarding surgical approach and intra-operative positioning for the THA, spinal and pelvic radiographic parameters, acetabular and femoral component positioning, head size and bearing type. The authors would like to

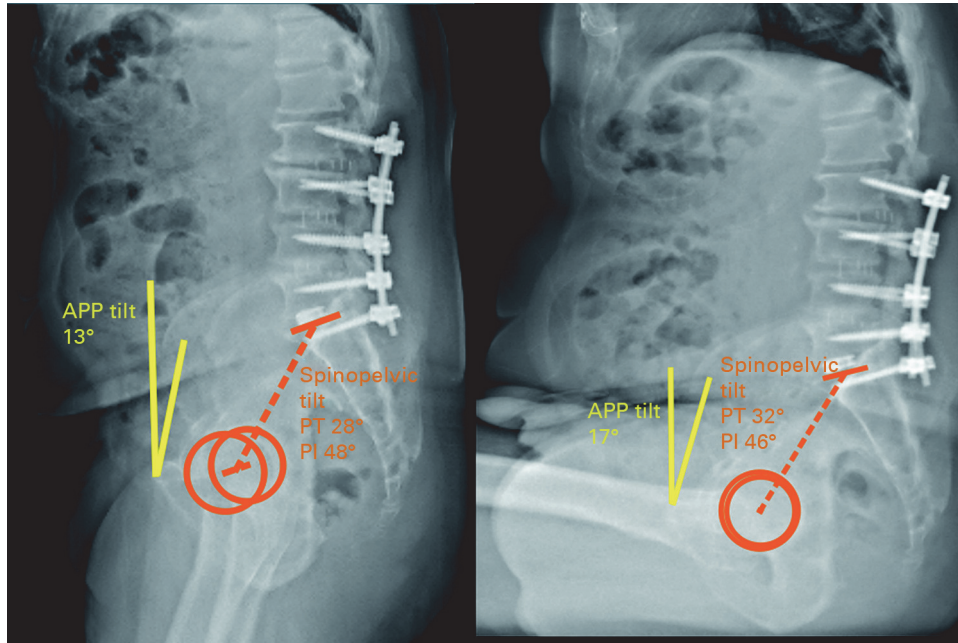


Fig. 2

Standing (left) and sitting (right) radiographs of a patient with L2-Sacrum lumbar fusion. Note the smaller change in pelvic tilt (PT) with change in posture when compared with the un-fused spine in Figure 1 (APP, anterior pelvic plane; PI, pelvis incidence).

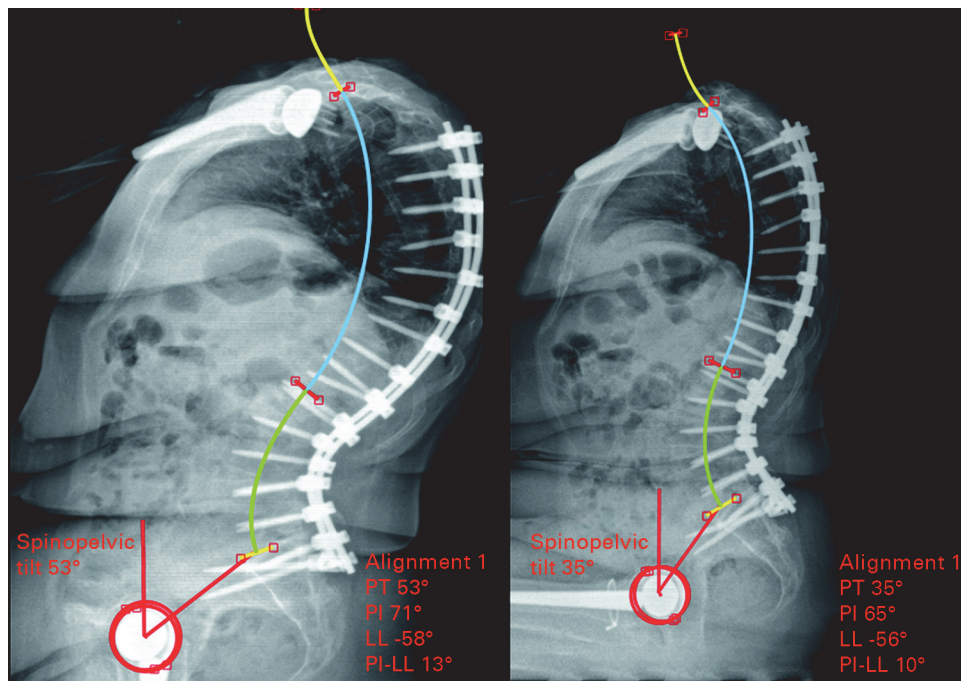


Fig. 3

Standing (left) and sitting (right) radiographs of a patient who underwent high thoracic to pelvis fusion for spinal deformity. Note that pelvic tilt (PT) paradoxically reduces (tilts anteriorly) in sitting (PI, pelvis incidence; LL, lumbar lordosis).

see more comprehensive multicentre prospective databases to help delineate the relative contributions of each of these factors.

Lastly, we were unable to analyse dislocation after 8+ level thoracolumbar fusions as the cohort was too small to

allow for appropriately powered comparisons with the other groups. Further investigation of the effect of 8+ level fusion on the rate of hip dislocation will be undertaken to establish whether this group of patients is likely to have the highest risk of hip dislocation.

The significance of this study is that it establishes the scale of the problem of dislocation in patients who have undergone previous spinal fusion and forms a basis for discussion as part of the process of informed consent for THA.

Patients undergoing primary THA have a higher rate of dislocation if they have previously had a lumbar spinal fusion. When matched for age and gender, patients with a 1 to 2-level lumbar fusion have a 1.87× risk of dislocation, and patients with a 3 to 7-level fusion a 3.13× risk of dislocation compared with patients who have not had a lumbar fusion.



Take home message:

- Lumbar spinal fusion increases the risk of dislocation following THA.

- Dislocation risk increases with increasing number of fused lumbar spinal vertebrae (1.93× for 1 to 2-level fusions, 2.77× for 3 to 7-level fusions).

Author contributions:

A. Buckland: Study design, Data collection, Statistics, Manuscript draft, Critical review of draft.

V. Puvanesarajah: Data collection, Statistics, Manuscript draft, Critical review of draft.

J. Vigdorichik: Study design, Data collection, Manuscript draft, Critical review of draft.

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