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Original Article

Predictive parameters for the antecedent development of hip pathology associated with long segment fusions to the pelvis for the treatment of adult spinal deformity

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Abstract

Background: The surgical treatment of adult scoliosis frequently involves long segment fusions across the lumbosacral joints that redistribute tremendous amounts of force to the remaining mobile spinal segments as well as to the pelvis and hip joints. Whether or not these forces increase the risk of femoral bone pathology remains unknown. The aim of this study is to determine the correlation between long segment spinal fusions to the pelvis and the antecedent development of degenerative hip pathologies as well as what predictive patient characteristics, if any, correlate with their development.

Methods: A retrospective chart review of all long segment fusions to the pelvis for adult degenerative deformity operated on by the senior author at the Duke Spine Center from February 2008 to March 2014 was undertaken. Enrolment criteria included all available demographic, surgical, and clinical outcome data as well as pre and postoperative hip pathology assessment. All patients had prospectively collected outcome measures and a minimum 2-year follow-up. Multivariable logistic regression analysis was performed comparing the incidence of preoperative hip pain and antecedent postoperative hip pain as a function of age, gender, body mass index (BMI), and number of spinal levels fused.

Results: In total, 194 patients were enrolled in this study. Of those, 116 patients (60%) reported no hip pain prior to surgery. Eighty-three patients (71.6%) remained hip pain free, whereas 33 patients (28.5%) developed new postoperative hip pain. Age, gender, and BMI were not significant among those who went on to develop hip pain postoperatively ($P < 0.0651$, 0.3491, and 0.1021, respectively). Of the 78 patients with preoperative hip pain, 20 patients (25.6%) continued to have

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hip pain postoperatively, whereas 58 patients reported improvement in the hip pain after long segment fusion for correction of their deformity, a 74.4% rate of reduction. Age, gender, and BMI were not significant among those who continued to have hip pain postoperatively ($P < 0.4386$, 0.4637, and 0.2545, respectively). Number of levels fused was not a significant factor in the development of hip pain in either patient population; patients without preoperative pain who developed pain postoperatively ($P < 0.1407$) as well as patients with preoperative pain who continued to have pain postoperatively ($P < 0.0772$).

Conclusion: This study demonstrates that long segment lumbosacral fusions are not associated with an increase in postoperative hip pathology. Age, gender, BMI, and levels fused do not correlate with the development of postoperative hip pain. The restoration of spinal alignment with long segment fusions may actually decrease the risk of developing femoral bone pathology and have a protective effect on the hip.

Key Words: Adult spine deformity, degenerative spine disease, hip pain, long segment fusion, lumbar spondylosis, pelvis, sacrum, sagittal balance, spinal alignment, spine fusion

INTRODUCTION

With advances in medicine, the US adult population is rapidly expanding, while staying more active.[17] The prevalence of adult spinal deformity in this population is increasing with a rate of nearly of 70%.[12,24] Degenerative spinal deformities can be progressive, causing significant back pain as well as neurologic sequelae such as radiculopathies and claudication. Furthermore, patients may incur muscle fatigue due to coronal and sagittal plane imbalances. These deformities can also have a negative psychological impact from the visible deformity.[1,12] Previous treatment of scoliotic deformity has focused on correction of the deformity in the coronal plane, however, more recently it has been shown that correction of the sagittal deformity and better alignment in the sagittal plane has the biggest impact on patients' quality of life.[5,12]

Treatment of adult degenerative spinal deformity often requires multilevel spinal decompression, with corrective osteotomies and arthrodesis to the sacrum and pelvis.[24] These long segment fusions exert significant force and stress upon the remaining mobile spinal segments as well as causing abnormal motion patterns in adjacent unfused joints.[2,9,15,16,21,26] The increased stress on the unfused adjacent segments may lead to degeneration necessitating additional surgical intervention consisting of possible decompression fusion, or even corrective osteosteomy.[2,22] The addition of iliac screw fixation with long segment spinal fusion provides greater support and is protective of sacral screw fixation.[14,28] Greater supraphysiologic force is seen by the bony pelvis and hip joints which causes strain on these joints and could result in accelerated degenerative changes such as osteoarthritis or fracture.[20] Therefore, the primary aim of this study was to determine if long segment spinal fusions to the sacrum and pelvis correlate with the antecedent development of degenerative hip pathologies and to determine any predictive features associated with the antecedent development of degenerative hip pathologies after these long spinal fusions to the sacrum and pelvis.

MATERIALS AND METHODS

This study was based on a retrospective chart review of all patients who underwent long segment thoracolumbar fusion to the sacrum and pelvis performed by the senior author at the Duke Spine Center from February 2008 to March 2014. Prospectively collected demographic, surgical, and functional outcomes data as well as pre and postoperative hip pain assessment were recorded.

Institutional Review Board approval was obtained prior to study initiation. We included patients older than 18 years of age with either an idiopathic deformity or a degenerative spinal deformity with the primary complaint of back pain with associated neurogenic claudication or radiculopathy. Degree of deformity was assessed on standard scoliosis films by the senior author. Surgical corrective procedure as well as number of spinal levels fused was recorded. All patients had functional assessment data collected at the baseline and then post intervention at regular intervals, with most patients having greater than 1 year of follow up. Baseline hip pain assessment was gathered from the patients' histories preoperatively as well as from patients' history postoperatively or patients' specific concern. Based on the degree and duration of hip discomfort, patients were then referred to Orthopedics for evaluation, and any

available orthopedic recommendation or intervention, if available, was recorded.

All data were collected and analyzed in aggregate form. All parametric data were expressed as means ± standard deviation (SD). A multivariable logistic regression model was used to compare the incidence of preoperative hip pain and the antecedent development of postoperative hip pain as a function of age, gender, body mass index (BMI), and the number of spinal levels fused. Statistical significance was set at a *P* value less than 0.05.

RESULTS

One hundred and ninety-four patients met the inclusion criteria for this study, with 141 female and 53 male patients [Table 1]. The average patient age was 64 ± 12.6 years with a range of 20–85 years. The mean BMI was 28.6 ± 6.6 kg/m^2, with BMI ranging from 16.2 kg/m^2 to 53.1 kg/m^2. Prior to any surgical intervention, 116 patients were free of hip pain. Seventy-eight patients had hip pain prior to surgical correction of their deformity. In the patients who had hip pain preoperatively, age had a statistically significant correlation ($P < 0.0169$). Gender and BMI did not have a statistically significant correlation with preoperative hip pain ($P < 0.4572$ and $P < 0.1713$, respectively). After surgical correction of their deformity, 141 patients did not complain of hip pain. Fifty-three patients developed new or persistent hip pain after surgery. Age and BMI approached statistical significance ($P < 0.0539$ and $P < 0.0515$, respectively). Gender did not have a statistical significant correlation ($P < 0.7809$).

In the group of patients without hip pain prior to long segment thoracolumbar fusion to the sacrum or pelvis, 83 (70%) patients of the total 116 patients remained hip pain free after surgical intervention. Thirty-three (30%) patients went on to develop postoperative hip pain after deformity correction surgery with long segment fusion to the sacrum and pelvis. Age ($P < 0.0651$), gender ($P < 0.3491$), and BMI ($P < 0.1021$) did not have any statistically significant association with the development of hip pain after deformity correction in patients without preoperative hip pain.

Of the 78 patients that complained of hip pain prior to surgery, 20 patients (26%) reported no change in their hip pain after long segment thoracolumbar fusion to the sacrum or pelvis. Fifty-eight patients reported improvement in their hip pain postoperatively, an approximate 74% reduction. Age ($P < 0.4385$), gender ($P < 0.4637$), and BMI ($P < 0.2545$) did not have any statistical significant correlation with the persistence of hip pain after deformity correction among patients with preoperative hip pain.

Long segment fusion was defined as a spinal fusion surgery involving at least 3 or more spinal levels. In the patient group who had no hip pain before surgery, there was an average of 9 (interquartile range) spinal levels fused for their deformity correction surgery, with a range of 3 spinal levels to a maximum of 15 levels. The most frequent number of levels fused in this study were 8, 9, 12, and 15 which correlated with T10-sacrum/pelvis, T9-sacrum/pelvis, T6-sacrum/pelvis, and T3-sacrum/pelvis, respectively. The corresponding frequencies were 45.7%, 10.3%, 12.1%, and 10.3%, respectively, [Table 2]. The group of patients suffering from hip pain prior to surgery underwent an average spinal fusion surgery of 9 spinal levels, with a range of 3 levels fused to a maximum of 17 spinal levels fused. The most frequent number of spinal levels fused were 8, 9, 12, and 15 with a corresponding frequency of 47.4%, 10.3%, 16.7%, and 11.5% respectively, [Table 2]. The number of spinal levels fused did not have statistical significance in the development of hip pain postoperatively in the patients who did not have hip pain prior to surgical

Table 1: Patient demographics

Total patients (No.)	194
Pre-op hip pain (No.)	116
No Pre-op hip pain (No.)	78
Age	
Mean±SD	64±12.6 years
Range	20-85 years
Gender	
Males	53
Females	141
BMI	
Mean±SD	28.6±6.6 Kg/m^2
Range	16.2-53.1 Kg/m^2
Levels fused	9.2±3.1

Table 2: Frequency of levels fused in patients with pre-operative hip pain vs. no hip pain

No. of levels fused	Patients without pre-op hip pain: Frequency	Patients with pre-op hip pain: Frequency
3	5	1
4	5 (L2-pelvis)	6 (L2-pelvis)
5	1	0
6	3	0
7	5	1
8	53 (T10-pelvis)	37 (T10-pelvis)
9	12	8
11	2	1
12	14 (T6-pelvis)	13 (T6-pelvis)
13	1	0
14	3	0
15	12 (T3-pelvis)	9
16	0	1
17	0	1

intervention ($P < 0.1407$), [Table 3]. The number of spinal segments fused did not have statistical significance in the persistence of hip pain postoperatively in those patients who had hip pain preoperatively ($P < 0.0772$), [Table 4].

DISCUSSION

The pelvis plays a pivotal role in maintaining global sagittal alignment. There is a harmonious and synergistic interplay between the spine and pelvis to maintain a healthy sagittal balance. Through compensatory mechanisms such as bending of the knees, uncovering the hip joint, and modulating the tilt of the pelvis can influence the spine by adjusting the lumbar lordosis.[29] These compensatory mechanisms require a significant amount of energy to help maintain a normal alignment.[12] Spinopelvic alignment is also important in regards to the hip joint. It has been known that degenerative pathologies of the spine also affect the hip through compensatory mechanism in the tilt of the pelvis, which place increased stress on the hip joints which can lead to osteoarthritis.[18,27,30]

With an aging population, the prevalence of degenerative spondyloarthropathies increases.[17] Offierski and MacNab in 1983 described the complex of interrelated symptoms affecting the hip and spine concurrently. Osteoarthritis of the hip can lead to a fixed flexion deformity of the hip joint, which in turn may rotate the pelvis forward. To compensate, the lumbar spine will become hyperlordotic to maintain normal sagittal balance.[18] Scoliosis can cause an abnormal pelvic orientation to compensate and put the spine back into an economical sagittal posture.[12,18] These changes to the tilt of the pelvis can encourage degeneration of the hip joint and cause hip discomfort. This is confirmed in our study. In the group of patients who complained of preexisting hip discomfort prior to any surgical deformity correction, we found that there was a statistical correlation between age and the presence of preexisting hip pathology. Interestingly though, we did not find a statistical correlation between BMI and the existence of hip pathology in those patients. When looking at all the patients after surgical correction of their spinal deformity, we found that age and BMI approached statistical significance among those postoperative patients who had hip pain. It has been shown that physical deconditioning, especially weakness of the lower back musculature or muscle spasms, can exacerbate low back pain and cause reduction in the nature lordosis of the lower back. Loss of lumbar lordosis affects spinopelvic alignment resulting in increased stress on the hip extensor musculature and hip joint.[6] Long segment degenerative deformity correction are large surgeries with significant muscle disruption, postoperative pain consideration, and a great physiologic stressor to the patient requiring long intensive care unit stay.[1] This is physically demanding for the patient and can leave them deconditioned postoperatively making the recovery more protracted in the older patients as well as more physiologically demanding in the patients with a larger BMI.

Table 3: Frequency of post-operative hip pain by levels fused in patients without pre-operative hip pain

	Number of Levels fused											
	3	4	5	6	7	8	9	11	12	13	14	15
No post-op pain	4	4	0	2	5	41	8	2	7	1	2	7
Post-op Pain	1	1	1	1	0	12	4	0	7	0	1	5

Table 4: Frequency of post-operative hip pain by levels fused in patients with pre-operative hip pain

	Number of Levels fused									
	3	4	7	8	9	11	12	15	16	17
No post-op pain	0	3	1	28	5	0	12	7	1	1
Post-op Pain	1	3	0	9	3	1	1	2	0	0

Out of the patients who were hip pain free prior to the deformity correction, nearly 70% remained hip pain free postoperatively. However, 30% developed hip pain postoperatively. Long segment spinal fusion creates significant stress and transfer significant forces that to the remaining mobile spinal segments and joints. These long fusion masses also alter the biomechanical environment and load sharing capability of the adjacent joints.[3,8,19,25,31] These abnormally large forces can be transferred to the pelvic girdle and hip joints in long segment spinal fusions that anchor to the sacrum and pelvis and put strain on the hip.[2,20] We did not find a statistical correlation between age, gender, or BMI in the development of hip pain in these patients.

Among patients with baseline hip pain, we found a 74% approximate rate of reduction in hip symptoms after deformity correction. This was most likely due to restoration of their sagittal alignment and putting these patients into a more energy efficient posture with less need for them to rely on compensatory posture by the pelvis and hip joints.[12,18] In addition, by having their fusion mass anchored to the sacrum or pelvis, this adds an additional level of support and ability to disperse the significant forces for the fusion to the large bony ring of the pelvis.[2,11,20,28] We did not find a statistical significant correlation with age, gender, or BMI among the patients who had resolution of their hip discomfort postoperatively.

We also investigated whether the amount of spinal levels fused caused an increased rate of the antecedent development of hip pathology. The most frequent amount of spinal levels fused were 8, 9, 12, and 15 which correlated to T10-, T9-, T6-, T3-sacrum/pelvis,

respectively. These were the most frequent spinal fusions because these are biomechanically good spinal segments to end a fusion as they all avoid ending a long spinal fusion construct at either a transition point or apex of the thoracic or lumbar curves.[7] We did not find a statistical correlation between the number of spinal segments fused and the antecedent development of hip. Again, this most likely has to do with the tremendous amount of force being transferred to the stable construct with the force being dispersed over the sacropelvic area.[4,10,13,28] Moreover, by correcting the spinal deformity and improving the overall global sagittal balance, these patients rely less on compensatory mechanisms and remain in a more energy efficient posture.[12,30]

It is valuable to consider the study's limitations to best utilize the knowledge gained from our analysis. Of note, this was a single institution retrospective analysis, which included 194 patients from a single surgeon. The inherent weakness with this study is the small sample size and a single surgeon's experience, which makes it difficult to generalize the conclusions of this study. In addition, the determination of hip pain or hip pathology was subjective and was gathered from the patient's corresponding medical record, rather than having the patients undergo a formal orthopedic evaluation prior to and after long segment fusion. It is difficult to objectively quantify the amount and degree of hip pathology the patients had in this study. Furthermore, it is difficult to define if their pain was truly from the hip joint rather than from other areas referred to the hip. Finally, our main focus of this study was to determine if the amount of transferred force from long segment fusion to the pelvis caused increased degeneration of the mobile hip joint rather than the degree of deformity and its relationship to hip pathology. It is well known that better spinal alignment puts patients into a more economical and comfortable posture. In addition to achieving spinal balance, the sacroiliac joint must not be neglected. In a study performed by Boachie-Adjei *et al*., sacroiliac degeneration occurred in 75% of patients undergoing long segment fusion to the sacrum.[23] This could be potentially offset with stress shielding by sacroiliac fusion or terminating the construct at the ilium.[23] Therefore, this warrants a prospective study assessing patients' pre and postoperative spinal parameters and how they relate to hip pain after long segment spinal fusions to the pelvis. Despite these limitations, the data does reveal several interesting correlations that we feel are clinically significant.

CONCLUSION

This study shows that long segment fusions to the sacrum and pelvis are not associated with an increase in postoperative hip pathology. Age, gender, BMI, and levels fused did not correlate with development of postoperative hip pain. The restoration of spinal alignment with long segment fusions may actually decrease the risk of developing femoral bone pathology and have a protective effect on the end hip joint.

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Conflicts of interest
There are no conflicts of interest.

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