



Osteoporosis is underrecognized and undertreated in adult spinal deformity patients

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Background: Adult spinal deformity (ASD) patients may have osteoporosis, predisposing them to an increased risk for surgical complications. Prior studies have demonstrated that treating osteoporosis improves surgical outcomes. In this study we determine the prevalence of osteoporosis in ASD patients undergoing long spinal fusions and the rate at which osteoporosis is treated.

Methods: ASD patients who frequented either of two major academic medical centers from 2010 through 2019 were studied. All study participants were at least 40 years of age and endured a spinal fusion of at least seven vertebral levels. Medical records were explored for a diagnosis of osteoporosis via ICD-10 code and, if present, whether pharmacological treatment was prescribed. T-tests and chi-squared analyses were used to determine statistical significance.

Results: Three hundred ninety-nine patients matched the study's inclusion criteria. Among this group, 131 patients (32.8%) had been diagnosed with osteoporosis prior to surgery. With a mean age of 66.4 years, osteoporotic patients were on average three years older than non-osteoporotic ($P=0.002$) and more likely to be female (74.8% *vs.* 61.9%; $P=0.01$). At the time of surgery, 34.4% of osteoporotic patients were receiving pharmacological treatment. Although not statistically significant, women were more likely to receive medical treatment than men ($P=0.07$).

Conclusions: The prevalence of osteoporosis in ASD patients undergoing a long spinal fusion is substantially higher than that of the general population. Surgeons should have a low threshold for bone density testing in ASD patients. With only about one-third of osteoporotic patients treated, there is a classic "missed opportunity" in this population.

Keywords: Deformity; scoliosis; osteoporosis; surgical complications; fusions

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Introduction

Adult spinal deformity (ASD) can affect as many as half of all individuals over the age of sixty in the United States (1). While many patients have minimal to no symptoms, others have significant pain and dysfunction that can be compounded by concomitant central stenosis and other forms of nerve compression (2,3). The disease burden associated with ASD has been found to be higher than that of chronic conditions such as diabetes, chronic lung disease, congestive heart failure, and arthritis (3). As a result, many patients undergo surgical treatment that often involves a long spinal fusion for deformity correction (4). Despite recent advances in surgical technique and implant design (5,6), complications such as failure of hardware, proximal junctional kyphosis, and infection commonly arise (7,8).

As with any instrumented fusion, ASD surgery can be further complicated by the presence of osteoporosis, as low bone mineral density presents substantial fixation challenges (9). One study found that 9.5% of all osteoporotic patients also suffer from ASD symptoms (10). Other studies have found the incidence of spinal stenosis, fractures, and progressive deformities occur at higher rates among osteoporotic than non-osteoporotic patients (11,12). However, to our knowledge, no prior study has investigated the prevalence of osteoporosis among patients undergoing long spinal fusions for ASD. Prior study has demonstrated osteoporosis treatment improves outcomes of one level lumbar fusion (13). Extrapolating this to ASD surgery, treatment can only be initiated with detection. Therefore, the purpose of this study was to determine the prevalence of osteoporosis and frequency of its treatment in ASD patients undergoing long fusion.

We present the following article in accordance with the MDAR checklist (available at <http://dx.doi.org/10.21037/jss-20-668>).

Methods

ASD patients who underwent surgery at either of two major academic medical centers from 2010 through 2019 were eligible for this study. Patients who were at least 40 years of age at the time of surgery were included. Patients with documented evidence of a spinal tumor were excluded. Through the utilization of a research patient data registry (RPDR), ASD patients were identified via any of the following ICD-10 codes: M41.3X (thoracogenic scoliosis), M41.5X (other secondary scoliosis) M41.8X (other forms of

scoliosis), and M41.9X (scoliosis, unspecified). Within this group, patients who endured a spinal fusion of at least seven vertebral levels were filtered using the CPT codes 22843 (posterior segmental instrumentation, 7 to 12 vertebral segments) and 22844 (posterior segmental instrumentation, 13 or more vertebral segments).

Demographic data for each patient was obtained, including a history of osteoporosis (identified using ICD 10 codes M80.XX and M81.XX). Patient records were reviewed for treatment of osteoporosis with any of the following medications: teriparatide, abaloparatide, denosumab, raloxifene, or any bisphosphonate. Patients were considered to be treated for osteoporosis if any of the aforementioned medications was taken during for at least the immediate twelve weeks prior to surgery. The prevalence of osteoporosis who underwent a long spinal fusion was calculated. Demographic data was compared between osteoporotic patients who received treatment for osteoporosis and those who did not.

Statistical analysis

When analyzing categorical variables, such as patient sex or race, chi-square tests were utilized to determine P values. For continuous variables, such as patient age, two-tailed t-tests were utilized for purposes of determining statistical significance. Data was tabulated on the basis of osteoporosis status and whether patients were actively receiving treatment for such.

Ethical statement

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by approved by the institutional review board at both medical centers (No: 2018P001897) and individual consent for the retrospective analysis was waived.

Results

Among the initial pool of patients, 399 met inclusion criteria. Within this cohort, 131 patients (32.8%) were diagnosed with osteoporosis before their surgical procedure. *Table 1* provides summative demographic data among osteoporotic and non-osteoporotic patients. On average, osteoporotic patients were statistically older than non-osteoporotic patients by approximately three years (66.4 vs. 63.5, $P=0.002$). Osteoporotic patients also exhibited a

Table 1 Demographic data comparing osteoporotic and non-osteoporotic patients

	Osteoporotic		Non-Osteoporotic		Total		P value
	Value	SD or %	Value	SD or %	Value	SD or %	
Number of Patients	131	–	268	–	399	–	
Age	66	9	64	9	64	9	0
Sex							0
Male	33	0	102	0	135	0	
Female	98	1	166	1	264	1	
Race							
Caucasian	121	1	258	1	379	1	0
Black	2	0	4	0	6	0	
Asian/Middle Eastern	3	0	3	0	6	0	
Other	3	0	0	0	3	0	
Unknown	2	0	3	0	5	0	

Data has been adopted from Gupta A, Cha T, Schwab J, et al. Osteoporosis Increases the Likelihood of Revision Surgery Following a Long Spinal Fusion for Adult Spinal Deformity. *Spine J* 2021;21:134-140 (14).

higher proportion of females relative to non-osteoporotic patients (74.8% vs. 61.9%, $P=0.01$). Greater than 90% of patients in this study were Caucasian.

In total, 34.4% of osteoporotic patients were taking at least one anti-osteoporotic medication, while the majority were untreated. *Table 2* depicts comparisons of demographical data between osteoporotic patients who were treated for osteoporosis versus those who were not. Age and race between these groups did not differ, though there were more females on medications than males without reaching statistical significance ($P=0.07$).

Table 3 provides information relating to the medical treatment of osteoporosis among the study population. Bisphosphonates and teriparatide were the most commonly used medications, each were taken by approximately one-fifth of osteoporotic patients. On the other hand, both abaloparatide and raloxifene were prescribed to only 1.5% of ASD patients with osteoporosis. While 65.6% of patients did not undergo medical treatment of osteoporosis, 9.2% of patients received multiple medications as part of their treatment. Medication regimens are illustrated graphically in *Figure 1*.

Discussion

Our data are consistent with well-known demographics of osteoporosis, supporting its generalizability. That is,

both older age and the female gender are correlated with the incidence of osteoporosis (15-17). In addition, the current study showed approximately one-third of patients undergoing a long spinal fusion have a diagnosis of osteoporosis. More importantly, two-thirds of these patients were untreated.

The prevalence of osteoporosis in ASD patients reported in this study is higher than previous reports investigating the general population; Wright *et al.* (1) estimated that 10.3% of Americans above the age 50 are osteoporotic. While this proportion is higher than we would have anticipated, it may indeed underestimate the true incidence of low bone density in this population. Gupta *et al.* (18) concluded that for accurate measurement of bone mineral density in ASD patients, DEXA scans should be obtained from at least two anatomic locations other than the spine. While the International Society for Clinical Densitometry (ISCD) recommends obtaining DEXA scans from the spine and hip for patients being evaluated for osteoporosis (19), patients with ASD often show falsely elevated bone density in the spine. As a result, osteopenia or osteoporosis is missed in one in six ASD patients (18). This was likely the case in patient cohort as well.

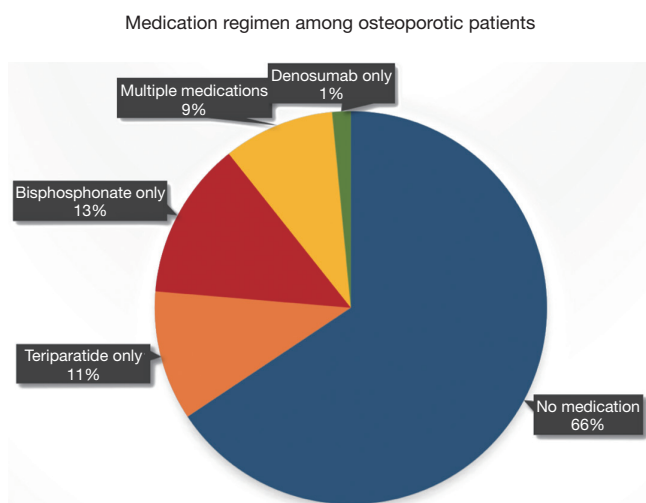
Roh *et al.* (20) recently showed that there are several reasons patients are not properly evaluated and treated for osteoporosis. Per their analysis, the leading cause for inadequate testing is patients' fear of finding an

Table 2 Demographic data comparing osteoporotic patients who are actively being treated with those who are not

	Medications		No Medications		All osteoporotic patients		P value
	Value	SD or %	Value	SD or %	Value	SD or %	
Number of Patients	45	–	86	–	131	–	
Age	67	7	66	9	66	8	0
Sex							
Male	7	0	26	0	33	0	0
Female	38	1	60	1	98	1	
Race							
Caucasian	39	1	82	1	121	1	0
Black	0	0	2	0	2	0	
Asian/Middle Eastern	2	0	1	0	3	0	
Other	2	0	1	0	3	0	
Unknown	2	0	0	0	2	0	

Table 3 Prescription of medications among osteoporotic patients

Medication	# patients receiving (%)
Abaloparatide	2 (1.5)
Bisphosphonate	29 (22.1)
Denosumab	5 (3.8)
Raloxifene	2 (1.5)
Teriparatide	22 (16.8)

**Figure 1** Distribution of treatment regimen among osteoporotic patients.

osteoporotic fracture. Other factors included patient health literacy, socioeconomic standing, and age, with younger patients less likely to seek testing or start (or continue) treatment for osteoporosis within one year of the diagnosis. These findings further underscore the need for vigilance in osteoporosis detection and treatment in ASD patients.

Beyond detection, previous data have shown that only one fourth of patients with fragility fractures subsequently received osteoporotic treatment consistent with recommended guidelines (21). This is consistent with the multitude of studies that show patients with recently diagnosed fragility fractures in various anatomical locations are most often not treated for osteoporosis, and thus represent the now well-known “missed opportunity (22,23).” Our study further supports this as only 34% of patients with osteoporosis were treated pharmacologically. Furthermore, our data showed that osteoporotic men were less likely to be treated, representing a group in which the opportunity is being disproportionately missed.

Osteoporosis has been shown to increase the rate of complications following spinal surgery (3). Considering that osteoporosis treatment is proven effective at improving bone density (24-27), it is prudent for surgeons to ensure that bone density not only be assessed but that treatment is initiated before surgery. As ASD surgery is already prone to complications, pathways to minimize this risk in an already frail group of patients are important. Further study will be needed to in fact determine the ideal pathway to most

positively impact outcomes.

While bisphosphonates can minimize bone loss, anabolic agents can effectively increase bone mass. As such, teriparatide use can lower the risk of vertebral fractures by 65%, and nonvertebral fractures by 35% (28). This agent is much more effective than bisphosphonates in preventing vertebral fractures (29). Despite these clear benefits, our study found that anabolic medications were used in fewer than 20% of ASD patients with osteoporosis. Regardless of the pharmacological treatment choice, patient education is critical to ensuring compliance to achieve adequate bone density optimization preoperatively.

This study has several limitations that should be acknowledged. Our data stems from two large academic centers in the New England region of the United States. Though demographical trends appears generalizable, it may not be widely applicable to other parts of the country or world. In addition, we also did not assess whether or not patients adhered to their medication regimen, as we relied on prescription records. We also were not able to fully assess their progress by virtue of periodic DEXA scans to assess improvement of bone mineral density over time; this data often was not collected. Our study also did not consider use of alternative osteoporotic treatments such as Vitamin D. Lastly, there might have been sound medical reasons that patient were not prescribed anti-osteoporotic medications. Our analysis was not able to detect patients who were osteopenic, and thus could distinguish between these patients and those with normal bone density. If anything, this further underestimated the proportion of patients with compromised bone quality.

Conclusions

The prevalence of osteoporosis in ASD patients undergoing a long spinal fusion is nearly 33%. Just over a third of these patients were treated pharmacologically for osteoporosis, meaning that nearly two thirds were left untreated. Male patients with osteoporosis were less likely to be treated for osteoporosis than women and are identified as a group who are a particularly “missed opportunity” (P=0.07). Given these data, surgeons should have a low threshold to test and treat for osteoporosis in ASD patients undergoing spinal fusions.

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Footnote

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Ethical Statement: The authors are accountable for accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by approved by the institutional review board at both medical centers (No: 2018P001897) and individual consent for the retrospective analysis was waived.

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