

Research Article

Prevalence of Work-related Musculoskeletal Disorders in Early Onset Scoliosis Surgeons

Ryan J McFadden¹, Grant D Hogue², William R Barfield¹, Michelle C Welborn³, Jason B Anari⁴, Robert F Murphy^{1*}

¹Department of Orthopaedics and Physical Medicine, Medical University of South Carolina, Charleston, SC, USA

²Boston Children's Hospital, Boston, MA, USA

³Shriners Hospital for Children Portland, (Department of Spine Surgery), Portland, OR, USA

⁴Children's Hospital of Philadelphia, Philadelphia, PA, USA

*Correspondence author: Robert F Murphy, MD, Department of Orthopaedics and Physical Medicine, Medical University of South Carolina, Charleston, SC, USA; Email: murphyr@musc.edu

Abstract

Background: Surgical treatment of Early Onset Scoliosis (EOS) involves operations with repetitive maneuvers that may put a surgeon at risk for a work-related Musculoskeletal Disorder (MSD). The purpose of this study was to evaluate the prevalence of MSDs that surgeons self-attributed to EOS operations.

Methods: Surgeons in an international study group were invited to participate in a 41-question survey and data was analyzed from surgeons with 5 or more years of experience post training. This included demographics, occurrence of an MSD directly attributed to repetitive EOS surgery, MSD anatomic location and treatment type.

Results: A total of 60 respondents qualified. Most respondents were male (51/60, 85%), with a mean age of 53 (range 36-78) and a mean of 20 years in practice (range 5-47). They reported a mean of 102 spine surgeries per year (range 12-300). A total of 117 MSDs were reported; the most common being cervical spine (30), lumbar spine (28) and wrist/hand (27). Of the 60 respondents, 49 (82%) reported at least one; 17 (30%) sustained 2 separate MSDs and 18 (30%) sustained 3 or more MSDs. Of those who reported at least one MSD, 29 respondents (59%) underwent treatment; the most common being injection (12/49, 25%), physical or occupational therapy (6/49, 12%) and surgery (6/49, 12%). There was a significant relationship between age and the prevalence of MSDs in the shoulder or rotator cuff region ($r=0.38$; $p=0.002$).

Conclusion: In a cohort of 60 EOS surgeons, more than 80% have sustained at least 1 MSD they self-attributed to EOS surgery, with the most frequent conditions affecting the cervical and lumbar spine and 58% reported >1 condition. Six participants (10%) underwent surgical treatment for an MSD they directly attributed to EOS surgery.

Level of Evidence: Level III

Keywords: Scoliosis; Early Onset Scoliosis; Musculoskeletal Disorders; Occupational Hazards

Introduction

Orthopaedic surgery is associated with several occupational hazards which pose physical and psychological health risks [1-3]. These burdens may negatively impact surgeon performance, career longevity and patient outcomes. Common occupational hazards in orthopaedic surgery include exposure to infection, radiation, surgical smoke, chemicals, auditory disturbance, and Musculoskeletal Disorders (MSDs) [1-2,4-8]. Trends in literature show a growing interest in understanding occupational hazards and opportunities to mitigate risk. Several studies have revealed high rates of MSDs among orthopaedic surgeons. A 2022 systematic review of 26 articles examining rates of MSDs among orthopaedists found that the overall prevalence of MSDs ranged from 44% to 97%. The most commonly afflicted regions were the lower back, hip/thigh and neck [9].

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Scoliosis surgery is frequently long in duration and often physically demanding, requiring surgeons to maintain ergonomically unfavorable postures and perform strenuous repetitive movements. While the surgical treatment of many types of scoliosis and spine deformity can be accomplished through a single procedure, the nature of early onset scoliosis poses unique challenges. The desire to control the spine deformity and promote continued growth of the chest and spine is accomplished through growth friendly surgery, which frequently involves multiple operations over the patient's growing years [10,11]. The repeat nature of these surgical interventions and their associated physical demands may predispose surgeons to acquiring MSDs.

Previous reports on work-related MSDs in 561 spine deformity surgeons found that the prevalence of MSDs was greatest in the lower back region followed by the neck and shoulder regions. These findings could be attributed to the sustained positions of the back, neck and upper extremities required in spine surgery [8]. However, this surgeon self-reported data did not examine which MSDs the surgeon attributed to the different types of scoliosis surgery.

The purpose of this study is to evaluate the prevalence of work-related MSDs that surgeons attributed specifically to repetitive EOS surgery, as well as treatments sought for those conditions. We also sought to survey surgeons' strategies they have utilized to mitigate risk of MSD. We hypothesized that more than half of surgeons would report at least one MSD that they attributed to repetitive EOS surgery and more than half would have employed some type of enabling technology or strain mitigation strategy to diminish further risks.

Materials and Methods

No identifying information from respondents was collected or reported, Institutional Review Board approval was not obtained. Members of an international study group focused on the growing spine in children were queried through email addresses. A 41-question online survey was developed and data were collected and managed using REDCap electronic data capture tools [13,14].

One hundred fifty-three members were contacted via email and were provided the study rationale and a link to participate in the survey. Two attempts were made to elicit participation over a one-month period. Data collected included demographics, occurrence of pain from an MSDs that the respondent directly attributed to repetitive EOS surgery, MSD location (neck, back, shoulder, elbow, wrist/hand, other) and treatment type (observation, bracing, immobilization, injection, physical therapy, surgery). The survey also included questions about interventions that may have been used to ameliorate the effects of repetitive spine surgery, such as use of selective wearing of lead garments, intraoperative advanced technology and physical fitness training.

IBM SPSS Statistics for Windows v27 was used for univariate and bivariate statistical analysis. The correlation between MSDs, treatment and exercise among the cohort of survey respondents was calculated. Chi-square and Pearson correlation tests were utilized to assess the relationships between total number of MSDs and number of MSDs in each anatomical region with age, number of years in practice, number of spine surgeries per year, use of advance technology and participation in routine exercise.

Results

There was a total of 60 respondents with five years or more experience of the 153 (39%) contacts. They were primarily male (51/60, 85%) with a mean age of 53 ± 12 years (range 36-78) and a mean of 20 ± 12 years in practice post training (range 5-47). Respondents reported a mean of 102 ± 63 spine surgeries per year (range 12-300).

A total of 117 MSDs were reported in this cohort; the mean number of MSDs was 2 ± 1.5 (range 0-6). The median number of MSDs was 2. Of the 60 respondents, 49 (82%) reported at least one MSD; 17 (30%) sustained 2 separate MSDs, 18 (30%) sustained 3 or more MSDs.

Table 1 shows the prevalence of reported MSD related pain by anatomical region. The highest prevalence was in the neck/cervical spine region (30/60, 50%) and the back/lumbar spine region (28/60, 47%) followed by the hand/wrist region (27/60, 45%), shoulder and rotator cuff region (18/60, 30%) and elbow region (12/60, 20%).

Table 2 shows self-reported diagnoses. The most commonly self-reported diagnoses for each anatomical region were as follows:

degenerative disc disease in the neck/cervical spine region; degenerative disk disease back/lumbar spine region; rotator cuff tear/strain; lateral and medial epicondylitis in the elbow region; general pain/stiffness, in the wrist/hand region.

Chi square analysis of the 49 surgeons who reported at least one MSD found that 29 respondents (59%) underwent active treatment ($p=0.022$). The most common treatment was injection (12/49, 25%), physical or occupational therapy (6/49, 12%) and surgery (6/49, 12%).

Surgeons reported employing advanced technology to mitigate the strain of EOS surgery including power pedicle screw implantation (33/60, 55%), navigation (31/60, 52%) and ratcheting pedicle screw drivers (33/60, 55%). Most surgeons reported participating in physical fitness programs, including aerobic conditioning (44/60, 73%), strength training (34/60, 57%) and specific exercises to train for spine surgery (10/60, 17%).

Pearson correlations between total number of MSDs, years of practice, caseload and BMI were not meaningfully correlated ($r \leq 0.2$) or statistically significant ($p \geq 0.05$). Serial bivariate analysis found a significant relationship between age and the prevalence MSDs in the shoulder or rotator cuff region ($r=0.30$; $p=0.022$). Participants 59 years or older had a 19 times greater odds ratio of reporting a shoulder or rotator cuff injury when compared to participants aged 43 years or younger (Fig. 1).

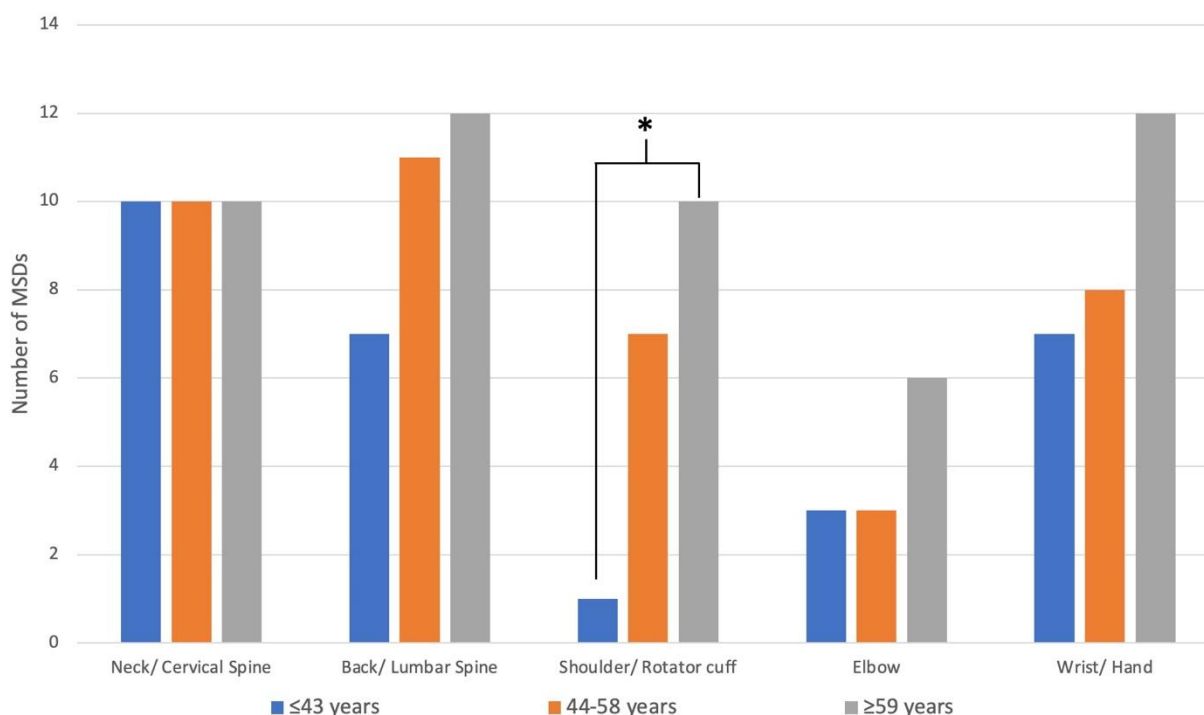


Figure 1: Number of MSDs per anatomical region for each age group. Participants 59 years or older had a 19 times greater odds ratio of reporting a shoulder or rotator cuff injury when compared to participants aged 43 years or younger.

Pain Location	Prevalence Among Respondents
Neck/Cervical Spine	30/60 (50.0%)
Back/Lumbar Spine	28/60 (46.7%)
Shoulder/Rotator cuff	18/60 (30.0%)
Elbow	12/60 (20.0%)
Wrist/Hand	27/60 (45.0%)
Other	2/60 (3.3%)

Table 1: Prevalence of MSDs by anatomical region.

Pain Location	Self-Reported Diagnoses
Neck/Cervical spine region	• Degenerative disc disease (n=6) • Cervical sprain/strain (n=5) • Cervicalgia (n=3) • Disc herniation (n=2) • Radiculopathy (n=1) • Cervicothoracic junction pain (n=1) • IVD collapse (n=1) • Foraminal stenosis (n=1)
Back/Lumbar spine region	• Degenerative disc disease (n=6) • Lumbago (n=5) • Lumbar sprain/strain (n=5) • Spinal stenosis (n=3) • Herniated disc (n=3) • Degenerative spondylosis (n=1)
Shoulder/Rotator cuff region	• Rotator cuff strain/tear (n=5) • Labral tear (n=2) • Tendonitis (n=2) • General pain (n=2) • Biceps tendon rupture (n=1) • Degenerative joint disease (n=1) • Multidirectional instability (n=1)
Elbow region	• Lateral/medial epicondylitis (n=6) • Tendonitis (n=2) • Degenerative joint disease (n=1) • Radiocapitellar subluxation (n=1) • General pain (n=1)
Wrist/hand region	• General pain/stiffness (n=7) • Degenerative joint disease (n=7) • Trigger finger (n=3) • Carpal tunnel syndrome (n=3) • Sprain/tear (n=3) • Tendonitis (n=2) • Scapholunate advanced collapse (n=1) • De Quervain's tenosynovitis (n=1)
Other	• Degenerative joint disease of the knee (n=1) • Adult flatfoot deformity (n=1)

Table 2: Self-reported diagnoses across anatomic regions.

Discussion

In this survey of surgeons who treat EOS patients, 82% of respondents self-attributed at least one MSD to repetitive surgical treatment of EOS. Pain in the cervical (50%) and lumbar (47%) regions was most prevalent, followed by pain in the hand or wrist (45%) and shoulder or rotator cuff (30%) regions. The most common self-reported diagnoses were general pain/stiffness of the hand or wrist (12%), cervical degenerative disc disease (10%), lumbar degenerative disc disease (10%), lateral or medial epicondylitis (10%) and rotator cuff strain or tear (8%). Older surgeons were more likely to experience pain from an MSD in the shoulder or rotator cuff region relative to younger surgeons.

The occurrence of work-related MSK conditions has been illustrated by studies in several disciplines of medicine. Surveys of neurosurgeons, minimally invasive surgeons, ophthalmologists and dentists reported a prevalence of pain from work related MSDs in 87.9%, 90%, 66% and 62%, respectively [15-18]. Our reported rate of 82% appears to fall well within norms of other procedural disciplines. Pain from MSDs in the neck, back and shoulder were commonly reported.

Orthopaedic surgery can be a physically demanding specialty and there is ample evidence showing the high prevalence of work-related MSDs among this population. A 2020 survey of orthopedic surgeons and residents at two institutions found a prevalence of work-related MSDs in 87.5% of the cohort with 66% reporting neck pain. Additionally, age was found to be associated with an increase in the total number of anatomic regions affected [19]. Similar to our study, no correlation was found between gender, number of years in practice or caseload and number of MSDs [19]. Among a cohort of upper extremity surgeons, 86.4% reported occupational MSDs, the most common being lower back pain (26%). In comparison to the cohort of EOS surgeons in our study, this population had a much lower prevalence of neck pain (15%) but comparable rates of surgical treatment to our cohort [20]. In a 2022 survey of orthopedic surgeons, Swank, et al., recorded work-related MSDs in 66% of their survey respondents. The most commonly reported complaints were lower back pain (56%), neck pain (42%), rotator cuff tendinitis (33%) and carpal tunnel syndrome (33%) [21]. Similarly, a systematic review and meta-analysis by Epstein, et al., found that the most common sources of pain among surgeons and interventionalists were degenerative cervical spine disease, rotator cuff pathology, degenerative lumbar spine disease and carpal tunnel syndrome [22]. While pain in the lower back, neck and shoulder were most common in our cohort; carpal tunnel syndrome was reported in only 5% of our cohort.

Spine surgery is characterized by long operative times, non-neutral postures and forceful repetitive movements which may be strenuous to the musculoskeletal system. A survey of spine deformity surgeons of the Scoliosis Research Society showed high rates of work-related MSDs afflicting the lower back (62%) and neck (59%), as well as a correlation between age and shoulder, elbow and hand pain. Their results also showed a higher prevalence of neck pain than other specialties and 5 times higher rate of lumbar disc degeneration relative to the general population.⁸ Considering the procedural similarities between the cohort of SRS members and our cohort of EOS surgeons, it is not surprising that the prevalence and location of MSDs were comparable. While rates of MSDs per anatomical region were higher among SRS members relative to our cohort of EOS surgeons, the most commonly afflicted areas were the same. Interestingly, age was only correlated with an increased prevalence of MSDs in the shoulder region in our cohort and contrary to our findings, surgical volume was a predictor of neck pain.

We recognize that there may be similarities between the aforementioned work by Auerbach, et al. and our current study. Many of members of the surveyed pediatric spine study group may be concomitant members of the Scoliosis Research Society and may have completed the prior survey. However, that work was published over 12 years ago and an update on MSDs in spine deformity surgeons, as well as the new survey data on employment of technology and physical fitness strategies to mitigate further risk, adds value to the literature. Additionally, the SRS contains a reasonable percentage of spinal deformity surgeons who treat adults with single stage surgery and we sought to intentionally investigate surgeon attributions of repetitive EOS surgery to MSDs.

The alarmingly high prevalence of work-related MSD conditions across surgical specialties highlights the need for ergonomic practices in the operating room to mitigate risk of injury to surgeons. In the recent review by Patel, et al., they highlight the operating table height to be adjusted to approximately 70% to 80% of resting elbow height and screw insertion being done at 5 to 10 cm below. Pediatric spine deformity surgeons must remain cognizant of table height position during the various aspects of the surgical procedure to optimize proper body biomechanics and minimize risk for MSDs [2]. A recent study by Alaqeel and Tanzer suggests that utilizing ergonomic principles from industry is a feasible and effective means of decreasing intraoperative MSK conditions among orthopaedic surgeons [23]. Claeson, et al., quantified changes in muscle exertion between manual and power assisted implantation of pedicle screws. They found that power assisted tools reduce average muscle exertion of the biceps, triceps and deltoid by 80% [9]. In our study, there was no correlation between use of power pedicle screw implantation, navigation or ratcheting pedicle screw drivers and decreased rates of MSDs. Nevertheless, the aforementioned studies suggest that implementing simple changes such as manipulating the operating room environment and utilizing assistive devices and tools which decrease muscle exertion and accommodate neutral posture can effectively protect against fatigue and lower the risk of MSK conditions [9,23]. Routine physical activity has also been shown to prevent MSDs; however, in our cohort no specific

physical fitness program was protective against the occurrence of MSDs [24]. Further research is required to understand occupational hazards faced in high-risk specialties and discover protective measures which will ensure surgeon safety and career longevity. Our study is not without limitations. This is a descriptive study which utilized a non-validated questionnaire to assess the prevalence of MSDs among EOS surgeons. The survey required respondents to self-report their MSD with no clinical evidence. We recognize that these factors could have inflated the prevalence of MSDs among this population. Finally, and very importantly, we recognize that surgeons who treat EOS also more frequently treat other pediatric spine deformity conditions, such as adolescent idiopathic scoliosis, Scheurmann kyphosis and spondylolysis/spondylolisthesis. These surgical procedures and the strain associated, may have had an effect on the occurrence or severity of MSDs in our respondents. We tried to be as intentional as possible in our survey asking surgeons to self-attribute MSDs to repetitive EOS surgery, but overlap could have certainly occurred (Fig. 2).

Survey - What is the burden of being an EOS Surgeon?

What is the burden of being an EOS Surgeon?

Please complete the survey below.

Thank you!

Age	
Gender	☐ Female ☐ Male ☐ Other ☐ Prefer not to say
Number of years in practice post training	
Number of spine surgeries (casts, fusions, growth friendly spine surgeries, revisions) performed in an average year	
Height	
Height units	☐ cm ☐ inches
Weight	
Weight units	☐ kg ☐ lbs
Glove Size (If two different sizes, list smaller size)	(e.g. 7, 7.5)
Have you ever had pain in any of the following areas from musculoskeletal issues that you attribute to activities performed as part of your duties as an EOS surgeon? (Check all that apply)	☐ Neck/Cervical Spine ☐ Back/Lumbar Spine ☐ Shoulder/Rotator cuff ☐ Elbow ☐ Wrist/Hand ☐ Other ☐ No injury
If comfortable, please list the diagnosis that you had for the neck/cervical spine region.	
If comfortable, please list diagnosis that you had for the back/lumbar spine region.	
If comfortable, please list diagnosis that you had for the shoulder/rotator cuff region.	
If comfortable, please list diagnosis that you had for the elbow region.	

Do you use any of the following technologies in performing EOS surgery? (check all that apply)	☐ Ratcheting pedicle screwdriver ☐ Power drill bit for pedicle finder ☐ Power/motorized pedicle screw implantation ☐ Power final torque/set screw break off ☐ Navigation ☐ Customized drill guide (e.g. Firefly) ☐ None of the above
Do you wear lead during any portion of spine surgery cases?	☐ Yes ☐ No
Over the course of your career, for what percentage of cases have you worn lead during any portion of the spine surgery?	☐ 0-33% ☐ 33-66% ☐ Over 66%
Do you participate in physical fitness activities?	☐ Yes ☐ No
What types of physical fitness do you participate in?	☐ Strength training ☐ Aerobic conditioning ☐ Recreational league sports ☐ Other
Other fitness activities	_____
Do you do any specific exercise to train your body for your job as a spine surgeon?	☐ Yes ☐ No
Please specify exercise(s)	_____
On average, how many days per week do you participate in physical fitness?	_____ (days)
If you are a female surgeon & have been pregnant, would you be willing to answer questions about your pregnancy?	☐ Yes ☐ No ☐ I am male ☐ I have never been pregnant
During pregnancy, did you (check all that apply)?	☐ Have increased pain in your back, neck or limbs ☐ Use double lead ☐ Axillary shielding
We would like to re-study participants in 5 years, and potentially 10 years. If you would be willing to participate in further studies, please include your email here.	_____
Comments	_____

If comfortable, please list diagnosis that you had for the wrist/hand region.	_____
If comfortable, please list diagnosis that you had for any other regions.	_____
Did you receive any treatment for this musculoskeletal condition?	☐ Yes ☐ No
Check all that apply	☐ Non-surgical observation ☐ Non-surgical bracing ☐ Non-surgical immobilization ☐ Non-surgical injection ☐ Physical therapy ☐ Surgical treatment ☐ Other
Other treatment type	_____
Have you had more than one musculoskeletal condition?	☐ Yes ☐ No
Did you receive treatment for this musculoskeletal condition?	☐ Yes ☐ No
Check all that apply	☐ Non-surgical observation ☐ Non-surgical bracing ☐ Non-surgical immobilization ☐ Non-surgical injection ☐ Physical therapy ☐ Surgical treatment ☐ Other
Other treatment type	_____
Have you had a third musculoskeletal condition?	☐ Yes ☐ No
Did you receive any treatment for this musculoskeletal condition?	☐ Yes ☐ No
Check all that apply	☐ Non-surgical observation ☐ Non-surgical bracing ☐ Non-surgical immobilization ☐ Non-surgical injection ☐ Physical therapy ☐ Surgical treatment ☐ Other
Other treatment type	_____

Figure 2: Survey of the surgeon.

Conclusion

In conclusion, the results of this study suggest that EOS surgeons sustain rates of work-related MSDs comparable to those of other medical disciplines and specialties of orthopaedics. The repetitive nature of the surgical intervention associated with EOS is similar to prior reports from other spinal deformity surgeons. Surgeons appear to be employed a wide range of enabling technology and fitness strategies to combat the stress and strain associated with repetitive EOS surgery. This evidence demonstrates the need for further investigation of the risk factors related to the occurrence of MSDs to allow surgeons to optimize performance and mitigate MSD risk.

Conflict of Interests

Michelle C. Welborn reports personal fees from AstraZeneca Rare Disease, DePuy, A Johnson & Johnson Company, Nuvasive, Orthopediatrics, Stryker and Synthes; research support from the Pediatric Orthopaedic Society of North America, Shriners Hospital for Children and ZimVie; board or committee member of the Pediatric Orthopaedic Society of North America, Pediatric Spine Study Group and the Scoliosis Research Society; and editorial or governing board of the Journal of Pediatric Orthopedics, Spine Journal and the Journal of Spine Deformity, outside the submitted work.

No authors have any additional conflicts of interest to disclose.

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