Incremental Impact of Lower Extremity Arthritis and Cervical Deformity on Patient-Reported Outcome Measures in Thoracolumbar Spinal Deformity Patients

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BACKGROUND AND OBJECTIVES: Thoracolumbar spinal deformity frequently coexists with cervical spine deformity (CD) and lower extremity osteoarthritis (OA), complicating management and compounding functional disability. This study investigates the additive burden of these conditions on patient-reported outcome measures (PROMs).

METHODS: This retrospective analysis assessed primary thoracolumbar deformity patients undergoing corrective surgery. Demographics, spinopelvic alignment, and PROMs were characterized. Severe CD was defined by ≥1 Ames criterion. Hip (HOA) and knee (KOA) OA were defined as Kellgren-Lawrence grade ≥3. Hierarchical regression and mixed-effects models evaluated the incremental and longitudinal impacts of these conditions on PROMs.

RESULTS: Among 816 patients (mean age 60.4 years, 67.1% female), 24.8% had CD, 43.7% HOA, and 40.4% KOA at baseline. Regression revealed that HOA worsened Oswestry Disability Index (ODI) total (R^2 = 0.056, *P* = .008), ODI Walking (R^2 = 0.121, *P* <.001), Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (R^2 = 0.108, *P* = .013), and Veterans RAND 12-Item Health Survey (VR-12) Physical Component Score (PCS) (R^2 = 0.098, *P* = .022). KOA primarily affected pain and psychosocial outcomes, including ODI Pain (R^2 = 0.033, *P* = .001), PROMIS Depression (R^2 = 0.018, *P* = .002), Scoliosis Research Society-22 Mental (R^2 = 0.033, *P* = .004), and VR-12 Mental Component Score (R^2 = 0.023, *P* = .025). CD contributed to ODI (R^2 = 0.063, *P* = .018) and Scoliosis Research Society-22 Activity (R^2 = 0.044, *P* = .032). Mixed-effects models showed improvements in all PROMs from baseline to 2-year follow-up (*P* <.001). However, HOA reduced improvements in ODI (3.41 points, *P* = .009), PROMIS Physical Function (1.37 points, *P* = .009), and VR-12 PCS (2.21 points, *P* = .003). KOA was associated with reduced walking tolerance (ODI Walking: 0.21 points, *P* = .020) and increased psychological burden (PROMIS Anxiety: 1.71 points, *P* = .007; VR-12 MCS: 2.01 points, *P* = .027). CD affected ODI Walking (0.51 points, *P* = .007) and VR-12 PCS (3.19 points, *P* = .043).

CONCLUSION: HOA patients undergoing deformity correction have worse preoperative physical disability and impaired postoperative functional recovery. KOA is associated with greater psychological burden. Severe CD has smaller physical impact. These findings highlight the need for individualized, multidisciplinary management strategies, with particular emphasis on early identification and targeted intervention for hip pathology to optimize outcomes.

KEY WORDS: Thoracolumbar deformity, Cervical deformity, Hip osteoarthritis, Knee osteoarthritis, Patient-reported outcome measures, Spinal fusion, Functional disability

ABBREVIATIONS: ASD, adult spine deformity; **CCI,** Charlson Comorbidity Index; **CD,** cervical deformity; **HOA,** hip osteoarthritis; **KOA,** knee osteoarthritis; **LL,** lumbar lordosis; **MCS,** Mental Component Score; **OA,** osteoarthritis; **ODI,** Oswestry Disability Index; **PCS,** Physical Component Score; **PI,** pelvic incidence; **PROMIS,** Patient-Reported Outcomes Measurement Information System; **PROMs,** patient-reported outcome measures; **SRS-22,** Scoliosis Research Society-22; **SVA,** sagittal vertical axis; **T1PA,** T1-pelvic angle; **VR-12,** Veterans RAND 12-Item Health Survey.

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Thoracolumbar spinal deformity often coexists with cervical spine deformity and lower extremity osteoarthritis (OA), posing a multifaceted clinical challenge for adult spine deformity (ASD) patients. Studies of ASD surgical cohorts show that the prevalence of cervical deformity (CD) ranges from 15% to 30% at baseline and up to 2 years postoperatively.[1-3] Moderate-to-severe hip OA (HOP) affects 34% to 54% of ASD patients, whereas moderate-to-severe knee OA (KOP) affects approximately 53% of these patients.[4,5] Each of these conditions (thoracolumbar deformity, CD, and lower extremity OA) independently contributes to pain, functional limitations, and diminished quality of life.[6,7] When they occur together, their combined effects may further impair patient-reported outcome measures (PROMs) and reduce overall quality of life.[8-11]

Postoperative correction of thoracolumbar deformity has consistently demonstrated improvements in pain, functional capacity, and overall PROMs.[2,5] In particular, restoring ideal spinopelvic alignment in the sagittal plane is essential to reducing mechanical stress on adjacent spinal levels and lower extremities.[12-15] However, degeneration or deformity of the hips, knees, or cervical spine can limit the degree of ideal alignment that can be achieved and maintained postoperatively. In such cases, management of their coexisting pathologies is also beneficial. Previous studies have shown that isolated correction of CD and lower extremity OA can also improve PROMs, contributing to better functional status.[6,16-18]

While CD and lower extremity OA have been studied separately in ASD populations, no previous investigation has thoroughly examined their combined incremental impact on PROMs.[19,20] Recognizing the additive burden of these conditions is necessary to make informed surgical decisions and provide accurate patient counseling. As such, this study investigated the impact of coexisting CD and lower extremity OA on PROMs at baseline and 2 years postoperatively in patients with thoracolumbar deformity. We hypothesized that CD and lower extremity OA would independently and cumulatively worsen disability both at baseline and after thoracolumbar deformity correction, even as outcomes improve as a result of surgical intervention.

METHODS

Study Design

This was a retrospective cohort analysis that used a multicenter prospective database containing data from 24 spine surgery centers across the United States. Institutional Review Board approval was obtained at each institution (approval number: 231842-20), and informed consent was acquired from each patient included in this study. Patients in this database were adults aged 18 years or older and met at least one of the following criteria for complex ASD:

1. Radiographic: pelvic incidence (PI)—lumbar lordosis (LL) ≥ 25°, T1-pelvic angle (T1PA) ≥ 30°, sagittal vertical axis (SVA) ≥15 cm, thoracic scoliosis ≥70°, thoracolumbar/lumbar scoliosis ≥50°, and global coronal malalignment ≥7 cm.
2. Procedural: posterior spinal fusion ≥12 levels and/or three-column osteotomy or anterior column resection.
3. Geriatric: age 65 years or older with surgical correction of thoracolumbar deformity involving instrumentation at ≥7 spinal segments.

Patients were excluded if they had a history of neuromuscular disorders, autoimmune conditions, active spinal tumors or infections, syndromic scoliosis, or spinal deformity due to acute trauma.

Study Population

The population of this study consisted of primary or revision thoracolumbar deformity patients with baseline data available. Patients with hip or knee arthroplasty were *excluded* to avoid confounding effects of joint replacement on PROMs and spinal alignment.

Data Collection

Demographic data (age, sex, Charlson Comorbidity Index [CCI], frailty score, sarcopenia) were recorded at baseline. Standing anteroposterior and lateral full-spine radiographs at baseline, 1-year, and 2-year follow-up were evaluated for coronal and sagittal parameters. Measurements on anteroposterior radiographs included the maximum coronal Cobb angle and on lateral radiographs included T1 slope minus cervical lordosis, C2-C7 lordosis, C7–S1 SVA, pelvic tilt, PI, PI–LL mismatch, T10–L2 kyphosis, L1-S1 lordosis, and L4-S1 lordosis.

CD was defined according to severe criteria by Ames et al: C2–C7 kyphosis ≥15°, T1 slope minus cervical lordosis > 35°, C2–C7 SVA ≥40 mm, McGregor slope ≥20°, or chin-brow vertical angle ≥ 25°.[21] HOA and KOA osteoarthritis were graded by 2 trained independent reviewers using Kellgren-Lawrence criteria, with Kellgren–Lawrence ≥3 indicating moderate-to-severe OA; a third reviewer resolved discrepancies between the 2 primary reviewers.

Finally, PROMs, including Oswestry Disability Index (ODI) and its subdomains, Scoliosis Research Society-22 (SRS-22) and its subdomains, Veterans RAND 12-Item Health Survey (VR-12) Physical Component Score (PCS) and Mental Component Score (MCS), and Patient-Reported Outcomes Measurement Information System (PROMIS) scores were collected at baseline, 1, and 2-year follow-up visits.

(Continued from previous page)

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Statistical Analysis

Descriptive statistics were computed for demographic variables, radiographic parameters, and PROMs. Hierarchical linear regression evaluated relationships between severe CD, thoracolumbar deformity, and HOA and KOA. Mixed-effects models adjusting for confounders such as age 60 years or older, sex, CCI, and sarcopenia evaluated longitudinal trends in patients with coexisting pathologies. Data were securely stored and analyzed using SPSS (Version 29, IBM Corp.). Statistical significance was set at P <.05.

RESULTS

Patient Characteristics

In total, 816 patients were included in this analysis (Table 1). The mean age was 60.4 years, 67.1% were female, mean CCI was 1.0, and mean frailty score was 3.3. At baseline, 24.8% of patients with thoracolumbar deformity exhibited severe CD, 13.2% had unilateral HOA, 30.5% had bilateral HOA, 12.7% had unilateral KOA, and 27.7% had bilateral KOA. Coexisting pathologies were also observed, with 11.8% presenting with both CD and HOA, 10.5% with both CD and KOA, 25.4% with both HOA and KOA, and 7.6% with all 3 conditions (CD, HOA, and KOA).

Patient-Reported Outcomes

Across all studied PROMs, statistically significant improvements were demonstrated over a 2-year follow-up period (**Supplemental Digital Content 1, Table 1**, http://links.lww.com/NEU/F122).

Radiographic Parameters

Over the same time period, both coronal and sagittal alignment parameters demonstrated statistically significant corrections, with notable improvements in coronal Cobb angles and PI–LL mismatch (**Supplemental Digital Content 1, Table 2**, http://links.lww.com/NEU/F122).

Incremental Baseline Impact on PROMs

Hierarchical regression analyses were conducted to assess the incremental contributions of HOA, KOA, and CD to various PROMs. The addition of HOA significantly improved the prediction of physical function and disability measures, including ODI total (R^2 = 0.063, P = .008), ODI Lifting (R^2 = 0.089, P < .001), ODI Walking (R^2 = 0.134, P < .001), and PROMIS Physical Function (R^2 = 0.110, P = .013). KOA primarily enhanced the models for pain and psychosocial outcomes, such as ODI Pain (R^2 = 0.033, P = .001), PROMIS Anxiety (R^2 = 0.038, P = .019), PROMIS Depression (R^2 = 0.019, P = .002), and SRS-22 Mental (R^2 = 0.033, P = .004). CD significantly contributed to the prediction of overall disability and activity-related measures, including ODI total (R^2 = 0.063, P = .018), ODI Walking (R^2 = 0.134, P = .019), and SRS-22 Activity (R^2 = 0.044, P = .032). Detailed statistical results are presented in Table 2 and visually represented in Figure.

TABLE 1. Baseline Patient Characteristics

Demographics	
Age	60.4 (15.2)
Age >60	523 (65.2)
Female	547 (67.1)
Charlson Comorbidity Index	1.02 (1.70)
Frailty score	3.33 (2.52)
Sarcopenia	53 (6.5)
Preoperative cervical and lower extremity conditions	
Cervical deformity	197 (24.8)
Unilateral hip OA	108 (13.2)
Bilateral hip OA	249 (30.5)
Unilateral knee OA	104 (12.7)
Bilateral knee OA	226 (27.7)
Cervical and hip OA	94 (11.8)
Cervical and knee OA	83 (10.5)
Hip and knee OA	207 (25.4)
All 3 conditions	60 (7.6)

OA, osteoarthritis.
Demographic and clinical characteristics for the patient cohort (n = 816). Data presented as mean (SD) or count (%).

Longitudinal Impact on PROMs

Mixed-effects models demonstrated that HOA had a consistent worsening impact worsened PROMs over a 2-year follow-up period (Table 3). Specifically, HOA patients had substantially higher ODI (3.41 points, P = .009), worse PROMIS Physical Function (1.37 points, P = .009), lower SRS-22 Satisfaction (0.14 points, P = .034), and worse VR-12 PCS (2.21 points, P = .003) scores, as well as worse scores in several other subdomains. KOA patients had substantially higher ODI Walking scores (0.21 points, P = .020), worse PROMIS Anxiety (1.71 points, P = .007) and PROMIS Depression (1.82 points, P = .007), and worse VR-12 MCS (2.01 points, P = .027). CD patients had substantially higher ODI Walking (0.51 points, P = .007) and worse VR-12 PCS (3.19 points, P = .043).

DISCUSSION

This study revealed that HOA is a significant and enduring obstacle to achieving optimal surgical outcomes in patients with thoracolumbar deformities. HOA demonstrated clear and lasting effects on both baseline disability and 2-year postoperative function across various patient-reported outcome measure

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TABLE 2. Hierarchical Regression Models Evaluating Incremental Contributions of Thoracolumbar Deformity, Cervical Deformity, and Hip/Knee Osteoarthritis to Patient-Reported Outcome Measures

PROM	Model 1 Thoracolumbar deformity R^2 (*P*-value)	Model 2 Hip OA R^2 (*P*-value)	Model 3 Knee OA R^2 (*P*-value)	Model 4 Cervical deformity R^2 (*P*-value)
ODI	**0.047 (<.001)**	**0.056 (.008)**	0.056 (.769)	**0.063 (.018)**
Pain	**0.021 (.004)**	0.020 (.690)	**0.033 (.001)**	0.037 (.075)
Personal care	**0.018 (.006)**	**0.030 (.002)**	0.030 (.744)	**0.039 (.011)**
Lifting	**0.065 (<.001)**	**0.083 (<.001)**	0.084 (.492)	**0.089 (.041)**
Walking	**0.107 (<.001)**	**0.121 (<.001)**	**0.128 (.018)**	**0.134 (.019)**
Sitting	**0.019 (.004)**	0.021 (.341)	0.023 (.188)	0.024 (.432)
Standing	**0.080 (<.001)**	**0.095 (<.001)**	0.096 (.405)	0.098 (.133)
Sleeping	0.010 (.083)	0.010 (.865)	0.011 (.516)	0.014 (.998)
Social life	**0.030 (<.001)**	**0.036 (.031)**	0.037 (.482)	0.040 (.153)
Traveling	**0.016 (.014)**	0.018 (.289)	0.021 (.099)	**0.027 (.026)**
Employment or homemaking	**0.040 (<.001)**	**0.047 (.019)**	0.040 (.793)	**0.043 (.048)**
PROMIS				
Anxiety	**0.030 (<.001)**	0.031 (.623)	**0.037 (.019)**	0.038 (.834)
Depression	0.005 (.443)	0.006 (.332)	**0.018 (.002)**	0.019 (.401)
Pain interference	**0.042 (<.001)**	0.044 (.215)	0.045 (.513)	0.049 (.083)
Physical Function	**0.101 (<.001)**	**0.108 (.013)**	0.102 (.612)	0.110 (.350)
Satisfaction w/discretionary social activities	**0.036 (<.001)**	0.039 (.137)	0.039 (.650)	0.043 (.103)
Satisfaction w/social roles	**0.055 (<.001)**	0.058 (.191)	0.060 (.174)	0.063 (.092)
SRS-22 total	0.011 (.066)	0.014 (.130)	0.018 (.071)	0.021 (.384)
Activity	**0.034 (<.001)**	0.037 (.089)	0.039 (.286)	**0.044 (.032)**
Pain	**0.028 (<.001)**	0.030 (.223)	0.030 (.993)	0.031 (.586)
Appearance	**0.015 (.018)**	0.019 (.080)	**0.029 (.006)**	0.030 (.292)
Mental	**0.022 (.002)**	0.022 (.527)	**0.033 (.004)**	0.033 (.753)
Satisfaction	0.006 (.314)	**0.013 (.019)**	0.015 (.219)	0.015 (.879)
VR-12				
PCS	**0.092 (<.001)**	**0.098 (.022)**	0.098 (.777)	0.101 (.110)
MCS	**0.016 (.016)**	0.016 (.503)	**0.023 (.025)**	0.023 (.835)

MCS, Mental Component Score; OA, osteoarthritis; ODI, Oswestry Disability Index; PCS, Physical Component Score; PROM, patient-reported outcome measure; PROMIS, Patient-Reported Outcomes Measurement Information System; SRS-22, Scoliosis Research Society-22 questionnaire; VR-12, Veterans RAND 12-Item Health Survey.
Hierarchical linear regression models showing incremental changes in R^2 and associated *P*-values when adding hip OA, knee OA, and cervical deformity predictors for each PROM. Significant values ($P < .05$) are bolded.

domains. These findings suggest early identification and potential preoperative intervention for HOA patients may improve patient outcomes. On the other hand, our analysis reveals that KOA, while less impactful on global physical function, is associated with impaired walking tolerance and a worsened psychological burden, particularly in mental health outcomes. Last, CD has a limited incremental impact on physical performance at baseline and over time.

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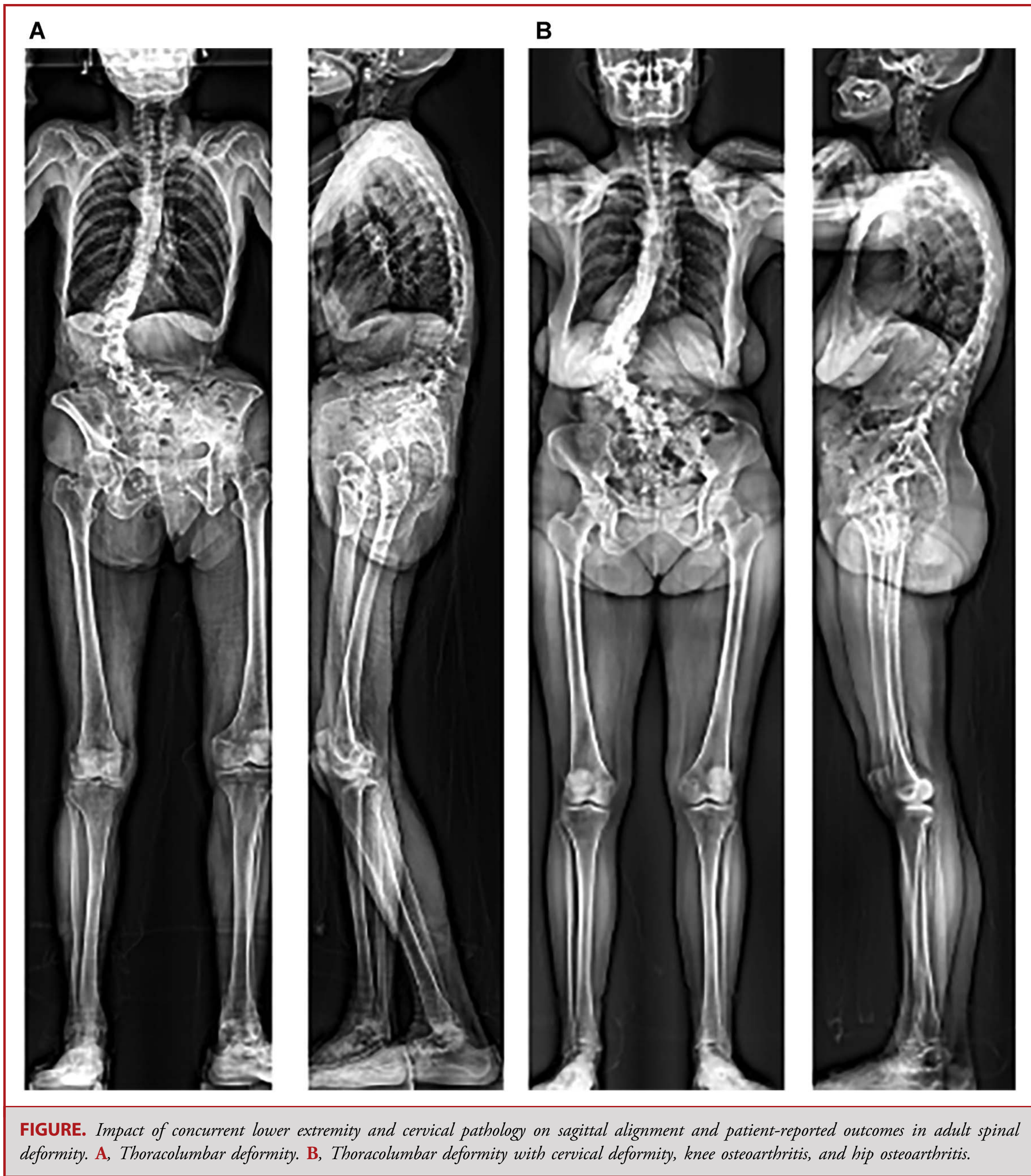

FIGURE. *Impact of concurrent lower extremity and cervical pathology on sagittal alignment and patient-reported outcomes in adult spinal deformity.* **A**, *Thoracolumbar deformity.* **B**, *Thoracolumbar deformity with cervical deformity, knee osteoarthritis, and hip osteoarthritis.*

Optimizing sagittal alignment is a crucial objective of deformity correction surgeries, as it reduces mechanical stress on adjacent spinal and lower extremity joints. When one spinal region is misaligned, adjacent segments or joints compensate to maintain an upright posture, potentially worsening existing spinopelvic deformities, accelerating degenerative joint disease, and impairing patient function.[4,22] Given the critical biomechanical role of the hip joint in maintaining spinal stability, mobility, and global sagittal alignment, degenerative hip pathology significantly limits compensatory mechanisms.[5,23] Our findings are consistent with previous literature that report HOA intensifies baseline disability and can continue to diminish postoperative improvements in pain, physical function, and overall quality of life.[3,5] Early identification and proactive management of HOA through comprehensive preoperative assessment and targeted intervention should be prioritized. Although debate persists regarding treatment order, these results support individualized surgical strategies that involve preoperative communication of hip and spine

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TABLE 3. Mixed-Effects Models Evaluating Longitudinal Impacts of Coexisting Pathology on Patient-Reported Outcome Measures

PROM	Hip OA	Knee OA	Cervical deformity
ODI	**3.41 (1.31) *P* = .009**	1.28 (1.31) *P* = .330	3.04 (2.46) *P* = .217
Pain	**0.24 (0.10) *P* = .019**	**−0.22 (0.10) *P* = .031**	0.02 (0.24) *P* = .947
Personal care	**0.19 (0.07) *P* = .005**	0.05 (0.07) *P* = .467	−0.01 (0.15) *P* = .967
Lifting	**0.30 (0.09) *P* = .001**	0.13 (0.09) *P* = .137	0.35 (0.20) *P* = .085
Walking	**0.27 (0.09) *P* = .003**	**0.21 (0.09) *P* = .020**	**0.51 (0.19) *P* = .007**
Sitting	−0.01 (0.08) *P* = .866	−0.05 (0.08) *P* = .480	−0.15 (0.16) *P* = .369
Standing	**0.24 (0.09) *P* = .007**	0.11 (0.09) *P* = .223	0.25 (0.19) *P* = .190
Sleeping	0.03 (0.09) *P* = .764	0.11 (0.09) *P* = .214	0.27 (0.18) *P* = .127
Social life	**0.23 (0.10) *P* = .021**	0.09 (0.10) *P* = .378	0.20 (0.20) *P* = .310
Traveling	0.11 (0.09) *P* = .220	0.15 (0.09) *P* = .102	0.01 (0.19) *P* = .944
Employment or homemaking	**0.20 (0.08) *P* = .014**	0.06 (0.08) *P* = .498	0.06 (0.17) *P* = .736
PROMIS			
Anxiety	−0.82 (0.64) *P* = .196	**1.71 (0.64) *P* = .007**	0.40 (1.27) *P* = .751
Depression	−1.11 (0.67) *P* = .102	**1.82 (0.68) *P* = .007**	2.09 (1.31) *P* = .111
Pain interference	1.11 (0.57) *P* = .054	0.69 (0.57) *P* = .227	0.73 (1.29) *P* = .570
Physical function	**−1.37 (0.52) *P* = .009**	−0.93 (0.52) *P* = .076	−0.03 (1.09) *P* = .978
Satisfaction w/discretionary social activities	−1.11 (0.63) *P* = .077	−0.70 (0.63) *P* = .262	−2.40 (1.43) *P* = .093
Satisfaction w/social roles	−0.85 (0.64) *P* = .182	**−1.26 (0.64) *P* = .048**	0.22 (1.46) *P* = .883
SRS-22 total	−0.05 (0.05) *P* = .257	−0.09 (0.05) *P* = .068	−0.11 (0.09) *P* = .250
Activity	−0.12 (0.06) *P* = .055	−0.09 (0.06) *P* = .152	−0.08 (0.12) *P* = .483
Pain	−0.11 (0.06) *P* = .100	−0.03 (0.06) *P* = .627	−0.04 (0.13) *P* = .753
Appearance	−0.06 (0.05) *P* = .267	**−0.12 (0.05) *P* = .019**	−0.14 (0.12) *P* = .217
Mental	0.10 (0.06) *P* = .102	**−0.16 (0.06) *P* = .009**	−0.17 (0.11) *P* = .122
Satisfaction	**−0.14 (0.06) *P* = .034**	0.06 (0.06) *P* = .377	−0.08 (0.16) *P* = .631
VR-12			
PCS	**−2.21 (0.75) *P* = .003**	−0.55 (0.75) *P* = .469	**−3.19 (1.58) *P* = .043**
MCS	0.99 (0.91) *P* = .276	**−2.01 (0.91) *P* = .027**	−1.47 (1.72) *P* = .392

CD, cervical deformity; HOA, hip osteoarthritis; KOA, knee osteoarthritis; MCS, Mental Component Score; ODI, Oswestry Disability Index; PCS, Physical Component Score; PROMs, patient-reported outcome measures; PROMIS, Patient-Reported Outcomes Measurement Information System; PROMs, patient-reported outcome measures; SRS-22, Scoliosis Research Society-22 questionnaire; VR-12, Veterans RAND 12-Item Health Survey.
Estimated marginal means, standard errors, and corresponding *P*-values for PROMs comparing outcomes across patients with HOA, KOA, and CD. Statistically significant values ($P < .05$) are bolded.

surgeons to improve long-term functional outcomes and maximize patient satisfaction.

Although CD has been recognized to contribute to subtle functional limitations in ASD, our study demonstrated a limited incremental impact on most PROMs and their subdomains. Several factors could account for these findings. Thoracolumbar deformity combined with the substantial impact of concurrent HOA may have overshadowed CD, making their incremental effect less detectable statistically.[4,5,24] In addition, thoracolumbar deformity correction can sometimes reveal latent cervical deficits, but if the deficits are not prominent enough, there may be no impact on PROMs over time.[25] Finally, the studied PROMs may not have

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been specific enough to capture the influence of CD effect on PROMs. Although more global health parameters were available and have previously been used to assess the impact of various pathologies on outcomes, in coexisting pathologies, such global parameters may not have been specific enough to evaluate the incremental impact of CD on PROMs.[9] Future studies may be required to disentangle the effects of CD on functional status.

Although KOA did not significantly affect most global physical PROMs at baseline or during follow-up, KOA does contribute most notably to mental health domains such as PROMIS Anxiety and Depression, SRS-22 Mental, and VR-12 MCS. Previous studies have shown that KOA can have a substantial impact on mental health, although the underlying relationship between the presence of KOA and concomitant anxiety/depression is poorly understood.[26] Paradoxically, KOA improved ODI Pain scores in our cohort, possibly indicating reduced perceived disability related to pain. This could potentially be explained by variations in subjective pain perceptions among patients with KOA and other types of OA, thus influencing how KOA patients interpret or report spinal pain.[27] Future work is needed to further evaluate the relationship between these 3 comorbidities and their impact on physical function and psychological well-being.

When managing patients with coexisting spine deformity and lower extremity OA, surgical priority requires careful consideration. Typically, addressing the more symptomatic condition first is recommended, especially if no major spinal realignment is planned. In cases that anticipate significant correction of pelvic tilt due to spine deformity correction, it is advisable to treat the ASD first.[23] Major realignment can alter acetabular cup orientation and spinopelvic kinematics, potentially reducing the risk of postoperative dislocation if hip arthroplasty is performed subsequently.[28] This sequential strategy aligns with previously established recommendations emphasizing individualized assessment based on the expected magnitude of correction and symptomatic presentation.

Limitations

This study has several potential limitations. First, its retrospective design introduces potential biases, including selection and information biases. Second, the cohort consisted of patients with thoracolumbar deformities, limiting generalizability to broader populations. Third, we were limited in our ability to analyze the long-term impact of surgical intervention on patients with CD, HOA, and KOA because of low sample sizes of these populations at 2 years. Finally, the spine-focused nature of our selected PROMs may fail to fully capture specific functional impairments related exclusively to CD or lower extremity pathologies, potentially underestimating their isolated effects. In addition, the duration of follow-up in this study may not fully capture the long-term impact of CD, particularly in cases where the upper instrumented vertebra is in the upper thoracic region. Previous research has shown a steady rate of extensions into the cervical spine in such cases, which could influence patient-reported outcomes over longer follow-up periods.

CONCLUSION

The presence of HOA significantly compounds baseline disability and limits postoperative functional recovery in thoracolumbar deformity patients undergoing spinal fusion. KOA, while less impactful on physical function, is also associated with greater psychological burden. Cervical deformity demonstrated minimal incremental impact on PROMs. Therefore, early identification and proactive intervention targeting physical and psychological aspects of deformity should be emphasized in the preoperative evaluation of patients with thoracolumbar deformity to enhance postsurgical outcomes in this population.

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Supplemental Digital Content 1, 2 Tables. Table 1. Patient-reported outcome measures at baseline, 1-year, and 2-year follow-up.
Table 2. Radiographic measurements at baseline, 1-year, and 2-year follow-up.

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