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The Prevalence of Hip Pathologies in Adolescent Idiopathic Scoliosis

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ABSTRACT

Background: Adolescent idiopathic scoliosis (AIS) is the most common form of abnormal spine curvature observed in patients age 10 to 18. Typically characterized by shoulder height and waistline asymmetry, AIS may drive uneven distribution of force in the hips, leading to increased rates of concurrent hip diagnoses. The relationship between AIS and concurrent hip diagnoses is underexplored in the literature, and to date, there has been little research comparing rates of hip diagnoses between patients with AIS and those unaffected.
Purpose: Assess differences in rates and clusters of hip diagnoses between patients with AIS and those unaffected.
Study design: Retrospective review of Healthcare Cost and Utilization Project's (HCUP) Nationwide Inpatient Sample (NIS).
Patient sample: 224,504 weighted inpatient discharges.
Outcome measures: Rates of hip diagnoses.
Methods: Patients in the NIS database (2005–2013) ages 10–18 years were isolated. Patients were grouped by those diagnosed with AIS (ICD-9: 737.30) and those unaffected. Patient groups were propensity score matched (PSM) for age. Means comparison tests assessed differences in demographic, comorbidity, and diagnosis profiles between patient groups for corresponding age categories. ICD-9 codes were used to identify specific hip diagnoses.
Results: Following PSM, 24,656 AIS and 24,656 unaffected patients were included. The AIS patient group was comprised of more females (66% vs 59%) and had lower rates of obesity (2.4% vs 3.5%, both $p < 0.001$). Overall, 1.1% of patients had at least one hip diagnosis: congenital deformity (0.31%), developmental dysplasia (0.24%), recurrent dislocation (0.18%), isolated dislocation (0.09%), osteonecrosis (0.08%), osteochondrosis (0.07%), acquired deformity (0.03%), and osteoarthritis (0.02%). AIS patients had lower rates of osteonecrosis (0.04% vs 0.12%, $p = 0.003$), but higher rates of all other hip diagnoses, including dysplasia (0.41% vs 0.07%, $p < 0.001$), recurrent dislocation (0.32% vs 0.03%, $p < 0.001$), isolated dislocation (0.13% vs 0.06%, $p < 0.001$), and osteoarthritis (0.04% vs 0.01%, $p = 0.084$. Co-occurrences of hip diagnoses were relatively rare, with 0.03% patients having more than one hip diagnosis. Rates of co-occurring hip diagnoses did not differ between AIS and unaffected groups (0.04% vs 0.02%, $p = 0.225$).
Conclusions: Compared to unaffected patients of similar ages, patients with AIS had higher overall rates of hip diagnoses, including dysplasia and recurrent dislocation. A higher trend of precocious osteoarthritis was also observed at a higher rate in AIS patients, although this difference was not statistically significant. Our results present an argument for surgical realignment in the coronal and sagittal planes to neutralize asymmetrical forces in the hips, and suggest the need for increased awareness and clinical screening for hip-related disorders in AIS patients.
Level of Evidence: III.

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1. Introduction

Adolescent Idiopathic Scoliosis is identified to affect 2–3% of adolescents but makes up 80–90% of the scoliosis-afflicted community. Typically characterized by shoulder height and waistline asymmetry, AIS may drive an uneven distribution of force through the hips, leading to increased rates of concurrent hip diagnoses.[1] Identification of AIS in patients is dependent on their Cobb's angle, which is closely related to the spinous process angle and rotation of the apical vertebra.[2] Alteration of this angle influences the biomechanical forces experienced, resulting in physiological compensatory mechanisms that impact both the sagittal and coronal planes.[3]

The dynamic lumbar-pelvic-femoral complex requires sagittal balance to appropriately distribute stress through the spine, hip, and lower limbs. Disruption of this network of structural components in patients that suffer from spinal deformities leads to disability.[4] Patients with AIS deal with the imbalanced distribution of stress with compensatory mechanisms such as extension of the hips and flexion of the knee joints, retroverting the pelvis significantly to alleviate the spinal pressure and myelopathic symptoms.[5–7] Malformation of the sagittal spine also impacts the degree of pelvic tilt, which leads to changes in the acetabular coverage.[8] This structural change can predispose those with spinal pathologies to hip pathologies due to the interaction between the pelvic attachment at the lumbosacral junction.[3,9]

Since both the spine curvature and the sacroiliac joint are affected in AIS patients, an asymmetric gait develops, predisposing them to multiple hip comorbidities such as hip dysplasia.[1,3] Abnormal symmetry in a person's coronal plane also contributes to this predicament since it leads to longer walking strides in AIS patients, which causes unbalanced reaction force vectors and added structural stress on the body.[10] However, the relationship between AIS and concurrent hip diagnoses is underexplored in the literature. To date, there has been little research comparing the rates of hip diagnoses between patients with and without AIS. This study aims to identify the difference in rates and clusters of hip diagnoses between patients with and without AIS.

2. Materials and methods

2.1. Data source and study design

This is a retrospective cohort study of patients pulled from the Nationwide Impatient Sample (NIS) database between the years 2005–2013. This database is one of the largest available all-payer database in the US. It also constitutes data from more than seven million hospital stays. More information about the NIS can be found at the following link: https://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp.

2.2. Study population

The study cohort's two groups, AIS-inflicted patients and unaffected patients, were identified through their International Classification of Diseases, Ninth Revision (ICD-9) code for idiopathic scoliosis (737.30). Both groups were further isolated based on restricting the age to $\geq$10 and $\leq$ 40 years old.

2.3. Variables of interest

Affected AIS and unaffected patients were assessed through demographics such as age and gender. The incidence of concurrent hip diagnoses were also assessed via ICD-9 identification (Appendix A) included acquired and congenital deformity, dislocation, dysplasia, enthesopathy, juvenile osteochondrosis, derangement, ankyloses, osteoarthritis, osteonecrosis, recurrent dislocation, and those that received procedures indicative of hip complications (73630, 73639, 75563, 8350, 83500, 83501, 83502, 83503, 8351, 83510, 83511, 83512, 83513, 7543, 75430, 75431, 75432, 75433, 75435, 71875, 7265, 7321, 71885, 71895, 71855, 71515, 71525, 71535, 71595, 71615, 73342, 73343, 71835, 8025).

2.4. Statistical analysis

The two cohort groups were propensity score matched for age and sex. Differences in demographics, comorbidities, and diagnosis profiles were assessed through means comparison tests. Co-occurring hip diagnoses rates for each group was identified through cross-tabulation with a significance level $p < 0.05$. All of the analyses were performed using SPSS software (v23.0, Armonk, NY, USA).

3. Results

3.1. Cohort overview

The total cohort of propensity score matched patients between the ages of 10–40 pulled from the NIS database was 49,378 (24,656 AIS, 24,656 unaffected). The AIS group was statistically older than the unaffected group (AIS: 14.5 $\pm$ 2.3 vs Unaffected: 14.2 $\pm$ 2.5 yrs, $p < 0.001$). There were also statistically more females within the affected group (66% vs 59%, $p < 0.001$) as well as lower rates of obesity (2.4% vs 3.5%, $p < 0.001$).

3.2. Hip diagnoses

Of the 49,378 patients included in this study, only 1.1% of patients had at least one hip diagnosis. The most common of these hip diagnoses were congenital deformity (0.31%), developmental dysplasia (0.24%), recurrent dislocation (0.18%), isolated dislocation (0.09%), osteonecrosis (0.08%), osteochondrosis (0.07%), acquired deformity (0.03%), and osteoarthritis (0.02%). However, when the two groups were analyzed separately, the AIS cohort displayed lower rates of osteonecrosis than the unaffected group (0.04% vs 0.12%, $p = 0.003$), but higher rates in the other hip diagnoses such as dysplasia (0.41% vs 0.07%, $p < 0.001$), recurrent dislocation (0.32% vs 0.03%, $p < 0.001$), isolated dislocation (0.13% vs 0.06%, $p < 0.001$), and osteoarthritis (0.04% vs 0.01%, $p = 0.084$). Patients undergoing at least one surgery for scoliosis correction and a concurrent hip diagnosis are displayed in Table 1.

3.3. Co-occurring

In the overall cohort, co-occurrences of hip diagnoses were relatively rare. Out of all the patients, only 0.03% of patients had more than one hip diagnosis. Rates of co-occurring hip diagnoses did not differ between AIS and unaffected patient groups (0.04% vs 0.02%, $p = 0.225$).

4. Discussion

Adult Idiopathic Scoliosis (AIS) is known to be associated with sagittal imbalance, sagittal malalignment, coronal imbalance, and coronal malalignment.[11] These impairments lead to compensatory mechanisms such as contralateral knee and hip flexion. Such spinopelvic adaptations can also lead to anteverted acetabular components, predisposing patients to clinical hip symptomatology.[12,13] With past research identifying this relationship between the spine and hip, the current study further solidifies the connection by examining the rates of co-occurring hip diagnoses in AIS patients.[3,12,14,15]

In our study, we found that, compared to unaffected patients of similar ages, patients with AIS had higher overall rates of hip diagnoses such as dysplasia and recurrent dislocation. Since AIS patients develop an array of compensatory mechanisms, it could take years for many abnormal mechanics to produce enough structural damage to result in symptoms and instability.[13,15] This could explain why dysplasia was still prevalent in our older, isolated cohort. Also, due to the disease's

association with the stability of the acetabulum coverage and the lumbosacral joint, it is not surprising that AIS patients were more likely to be diagnosed with dysplasia and hip dislocation than the unaffected cohort.[13]

Although many of the common hip diagnoses occurred more frequently in the AIS cohort, there were some notable exceptions. The most common hip pathology in the entire cohort was congenital deformity, yet there was no statistically significant difference in the rate of this diagnosis between both groups. This result makes sense since, by definition, AIS manifests in adolescence, well beyond the developmental timeframe of a congenital anomaly. Additionally, the AIS cohort displayed lower rates of osteonecrosis. This finding could be explained by the fact that alcohol-associated osteonecrosis, which is one of the most common causes of hip osteonecrosis, occurs more frequently in men, as opposed to our female-predominating cohort.[16]

Aside from hip diagnoses, AIS patients may have an increased risk profile to complications and morbidity. In a clinical study of early onset scoliosis patients, Segreto et al. found patients with concurrent musculoskeletal conditions were more likely to have internal organ anomalies.[17] This patient population have also been linked to intraspinal anomalies and neuroaxial abnormalities.[18–21] The significant role this plays in gait disturbance and performing daily activities makes this condition important to address early on, often requiring an intervention prior to scoliosis reconstruction.[21,22] The inherent risk of associated disease carried by these patients makes their medical treatment complex and unique. In a large cohort treated for early onset scoliosis, there was a higher prevalence of commonly associated conditions – hip dysplasia, torticollis, plagiocephaly, metatarsus adductus, and clubfoot.[23] An adolescent spine is important to monitor for its future impact on a patient's functionality. However, when observed, it is equally vital to look elsewhere for abnormalities and surgeons must remain vigilant in doing so while assessing a child.

If the hip diagnoses with an increased frequency in the AIS cohort were caused by the same underlying mechanism, one would expect these pathologies to manifest simultaneously. This may be true to some extent since the AIS group had a higher rate of co-occurring hip diagnoses (0.04% vs 0.02%), although this finding was not statistically significant ($p = 0.225$). Therefore, the root cause of these pathologies in AIS patients must be more nuanced than having an unbalanced load distribution through the hips. The severity of the spinal curvature and the compensatory patterns the patient has developed may influence the specific type of hip pathology the patient becomes susceptible to as the deformity progresses.[9] Understanding these subtle differences may provide greater insight into the underlying pathophysiology and ways to prevent concomitant hip problems in these patients.

Our study analyzed the group of AIS patients as a single cohort, but these patients can present with a wide range of deformities. Stratifying this group may help to uncover the precise biomechanical process that leads to specific hip pathologies. Additionally, future studies that prospectively monitor the hips through clinical evaluation and imaging could help to characterize the progression of hip pathology in these patients, opening the door to new screening tools and preventative measures. Combining this data to create a comprehensive model of the biomechanical forces induced by spinal deformities and subsequent compensatory mechanisms will ultimately be the key to unlocking surgical techniques or physical therapy regimens that alleviate the burden of hip deterioration in patients with AIS.

5. Conclusions

Compared to unaffected patients of similar ages, patients with AIS had higher rates of hip diagnoses, including dysplasia, dislocation, and osteoarthritis. However, there was no significant difference in rates of co-occurring hip diagnoses between AIS and unaffected patient groups, suggesting that there may be differences between patients with AIS that predispose them to specific hip problems. Overall, our results present an argument for surgical realignment in the coronal and sagittal planes to neutralize asymmetrical forces in the hips and suggest the need for increased awareness and clinical screening for hip-related disorders in AIS patients.

Ethical review committee statement

No IRB approval was needed as this is a retrospective study of data that is publicly available.

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Author contributions

Cole Bortz: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft. **Tyler Williamson:** Writing – Original Draft, Methodology, Conceptualization. **Sara Naessig:** Writing – Review & Editing, Visualization. **Ammar Adenwalla:** Writing – Review & Editing, Visualization. **Vivek Singh:** Writing – Review & Editing, Visualization. **Lara Passfall:** Writing – Review & Editing, Visualization. **Oscar Krol:** Writing – Review & Editing, Visualization. **Salman Ahmad:** Writing – Review & Editing, Visualization. **Navraj Sagoo:** Writing – Review & Editing, Visualization. **Bailey Imbo:** Writing – Review & Editing, Visualization. **Peter Tretiakov:** Writing – Review & Editing, Visualization. **Rachel Joujon-Roche:** Writing – Review & Editing, Visualization. **Kevin Moattari:** Writing – Review & Editing, Visualization. **Stephane Owusu-Sarpong:** Writing – Review & Editing. **Shaleen Vira:** Writing – Review & Editing, Visualization. **Bassel Diebo:** Writing – Review & Editing. **Peter G Passias:** Writing – Review & Editing, Visualization, Conceptualization, Supervision, Resources, Research Administration.

Table 1
Hip diagnoses with +1 surgeries.

Diagnosis	10–19	20–29	30–39	40–49	50–59	60–69	70+
Recurrent dislocation	0.30%	0.20%	0.10%	0.10%	0.10%	0.00%	0.00%
Acquired deformity	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Congenital deformity	0.50%	0.20%	0.30%	0.40%	0.20%	0.10%	0.00%
Dislocation	0.10%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%
Dysplasia	0.40%	0.10%	0.10%	0.10%	0.10%	0.00%	0.00%
Enthesopathy	0.00%	0.10%	0.10%	0.20%	0.20%	0.30%	0.40%
Juvenile Osteochondrosis	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Derangement	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ankylosis	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Osteoarthritis	0.10%	0.20%	0.50%	1.00%	2.60%	3.50%	3.10%
Osteonecrosis	0.10%	0.10%	0.20%	0.30%	0.30%	0.20%	0.20%

Declaration of competing interest

The following authors have conflicts of interest outside the current work:

Peter Gust Passias
Allosource: Other financial or material support
Cervical Scoliosis Research Society: Research support
Globus Medical: Paid presenter or speaker
Medicrea: Paid consultant
SpineWave: Paid consultant
Terumo: Paid consultant
Zimmer: Paid presenter or speaker
Shaleen Vira: Nothing to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2022.02.017.

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