Clinical and Radiographic Characteristics in Male and Female Adolescent Candidates for Idiopathic Scoliosis Surgery

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ABSTRACT: **Background:** Gender differences in adolescent idiopathic scoliosis (AIS) have been documented in curve progression, response to bracing, and outcomes of surgical treatment. However, limited information is available about the relation between gender and scoliosis curve patterns and radiographic characteristics.

Objectives: To evaluate the effect of gender on curve pattern and compare clinical and radiographic characteristics between male and female patients with AIS.

Methods: We conducted a retrospective review of prospectively collected data that compared clinical and radiographic characteristics between male and female surgical candidates. Demographic and clinical data including age at presentation, gender, family history of scoliosis, brace treatment history, clinical coronal balance, shoulder asymmetry, and hump size were recorded. All patients graded their pain with the use of a visual analogue scale (VAS) on a scale from 0 to 10. Radiographs of the spine were reviewed to determine the type of curve according to the Lenke classification, Cobb angle, thoracic kyphosis angle, and the Risser sign. Radiologic coronal balance was recorded. Curve flexibility was determined by measuring the thoracic and lumbar curve magnitude on side-bending radiographs.

Results: The study included 163 patients with AIS – 35 males and 128 females. Although a trend toward more flexible major thoracic curves in females was noticed, there was no statistically significant difference between the two groups.

Conclusions: In this study we were not able to demonstrate any clinical nor radiological statistical differences between male and female candidates for surgical treatment.

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KEY WORDS: gender, adolescent idiopathic scoliosis (AIS), gender differences, clinical and radiographic characteristics

Adolescent idiopathic scoliosis (AIS), curvature of the spine that occurs during pubertal growth, has an overwhelming female predominance [1]. Although female and male patients with AIS are equally affected with small scoliosis curves (Cobb angle about 10º), an increased female-to-male ratio is found in patients with larger Cobb angles [1,2].

Significant gender-based differences in the outcomes of treatment in AIS have been documented. Brace treatment can prevent progression of the scoliosis curve in skeletally immature patients [3,4]; however, it may have limited effect in male patients [5,6]. Varied results have been reported regarding the effects of gender on surgical correction of scoliosis. Sucato et al. [7] noted less curve correction in male patients with AIS than in female patients, although they showed similar curve rigidity. Others found that male patients with AIS may have similar curve correction but slightly more rigid primary curves than female patients [8,9]. Wang and co-authors [10], comparing the gender differences in curve patterns and radiographic characteristics in patients with AIS, found that atypical curve patterns were more predominant in male than in female patients with AIS and that there is higher rigidity of both thoracic and lumbar curves in male patients with AIS and severe curves [10].

We hypothesized that the female and male patients who are candidates for surgical treatment of scoliosis may have different clinical and radiographic characteristics. The purpose of this study was to evaluate the effect of gender on curve pattern and to compare clinical and radiographic characteristics between male and female patients with AIS.

PATIENTS AND METHODS

We studied prospectively collected data from a single institution. Included were all patients who were candidates for surgical treatment for AIS between January 2013 and December 2016 in our institution. None of the patients required surgery before their AIS correction. Data collection was carried out prospectively by a single observer (an orthopedic spine surgeon). Demographic and clinical data including age at presenta-

tion, gender, family history of scoliosis, brace treatment history, clinical coronal balance, shoulder asymmetry, and hump size were recorded.

The study was approved by the Institutional Review Board, and all procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

CLINICAL EVALUATION

Clinical coronal balance was determined by measuring the horizontal distance from a vertical line extended from the spinous process of the C7 vertebra relative to the gluteal cleft. Coronal decompensation was defined if this distance was > 2 cm. The rib hump was measured with a scoliometer. Using the scoliometer, we measured the rotary distortion of the torso, in degrees, while the patient was in a forward bending position. All ribs humps were measured, whether from thoracic or thoracolumbar curves. Shoulder asymmetry was defined as a 1-cm height difference between shoulders [11]. All patients graded their pain with the use of a visual analogue scale (VAS) on a scale from 0 to 10. The VAS was a 100 mm-length horizontal line anchored by word descriptors at each end: "no pain" on the left side and "maximal pain" on the right side.

RADIOGRAPHIC EVALUATION

Posteroanterior and lateral 1-meter standing preoperative radiographs of the spine were reviewed to determine the type of curve according to the Lenke classification, Cobb angle, thoracic kyphosis angle (measured from T5 to T12), and the Risser sign. Radiological coronal balance was measured using a radiological plumb line drawn from the center of the C7 endplate, and the distance from the line was measured to the center sacral vertical line (CSVL). Coronal decompensation was defined as > 2-cm distance from the radiologic plumb line to the CSVL. Curve flexibility was determined by measuring the thoracic and lumbar curves magnitude on the preoperative anteroposterior supine and standing right and left side-bending radiographs. Flexibility was calculated and expressed as a percentage of the initial curve as it was measured on the anteroposterior supine radiograph. All patients underwent magnetic resonance imaging (MRI) of the cervical, thoracic, and lumbar spine. The level of the conus medularis and the presence of any spinal anomaly was documented.

STATISTICAL ANALYSES

Data analysis was performed with the Statistical Package for the Social Sciences (version 12.0; SPSS, Inc., Chicago, IL, USA). Comparisons of chronological age, scoliosis curve severity, curve flexibility, thoracic kyphosis, hump size, shoulder asymmetry, plumb line, and VAS were performed with Student's *t*-test between female and male patients. The chi-square test was used to evaluate differences in the distribution of scoliosis curve patterns according to the surgical classification of AIS by Lenke et al. [12], Risser grade, usage of brace, and family history of scoliosis. Tests were conducted as two-tailed and the significance level was set at $P = 0.05$.

RESULTS

The study group comprised 163 patients with AIS, 35 males and 128 females. Female patients were, on average, slightly younger (15 vs. 16 years old), but there was no statistically significant difference in Risser grade compared with male patients ($P = 0.207$).

Fifty-five patients (34%) had a family history of scoliosis: 37% in the female group compared to only 23% in the male group. The difference between males and females was not statistically significant ($P = 0.159$).

Twelve of the male patients (34%) and 61 of the female patients (48%) were managed with a brace to prevent progression of the curve. The difference between the two groups was not statistically significant ($P = 0.183$). There was no statistically significant difference between males and females in hump size ($P = 0.273$), nor in the percentage of patients with asymmetry of the shoulders. We could not demonstrate a statistically significant difference between the two genders when evaluating clinical coronal balance ($P = 0.776$) and coronal decompensation (> 2-cm distance from the radiological plumb line to the CSVL) ($P = 0.823$).

When comparing the two groups with regard to the surgical classification of AIS by Lenke et al. [12], no significant difference was retrieved on the distribution of curve types. Main thoracic curve (Lenke type 1) was the most common type in both males and females [Table 1]. However, in females the second most common type was double thoracic curve (Lenke type 2), while in males it was thoracolumbar/lumbar-main thoracic (Lenke type 6) curve. There was no statistically significant difference in the lumbar spine modifier ($P = 0.269$) and the thoracic sagittal profile (0.652) between the two groups.

Side-bending X-ray films were used for analysis of curve flexibility between males and females. Although a trend toward

Table 1. Distribution of curve patterns in adolescent idiopathic scoliosis according to the Lenke classification

	Male	Female
Lenke 1	17	61
Lenke 2	4	26
Lenke 3	2	13
Lenke 4	3	3
Lenke 5	0	11
Lenke 6	9	14

Table 2. Comparison of different parameters between male and female surgical candidates

	Gender	Mean	*P*
Age (years)	Male	16.17	0.503
	Female	15.15	
VAS	Male	3.33	0.870
	Female	3.43	
Hump	Male	16.30	0.273
	Female	17.67	
Upper thoracic angle	Male	31.20	0.407
	Female	29.10	
Thoracic angle	Male	58.47	0.672
	Female	59.69	
Lumbar angle	Male	45.00	0.520
	Female	43.20	
Sagittal	Male	25.75	0.297
	Female	30.09	
Bending thoracic	Male	35.48	0.054
	Female	44.03	
Bending lumbar	Male	71.44	0.386
	Female	75.76	

more flexible major thoracic curves in females was noticed, there was no statistically significant difference between the two groups.

Table 2 summarizes different parameters that were compared between male and female surgical candidates.

DISCUSSION

Gender-related differences exist in many fields of medicine [13,14]. Previous studies comparing males and females with AIS have shown differences in the natural history of curve progression [1,2], namely, a higher incidence of atypical curve patterns in male than in female patients [10]. Differences between males and females were also demonstrated in response to brace treatment and to surgical intervention. In the current study we retrospectively analyzed clinical and radiographic characteristics of male and female patients with AIS who were candidates for surgery.

As in previous studies, half the patients with adolescent idiopathic scoliosis had Lenke type 1 curves [15]. In our study, male patients did not differ from female patients in their tendency toward thoracic involvement. Previous studies have shown that male patients tend to have larger curves [15]. However, although the difference was statistically significant, it was minimal with an average major curve of 56° ± 13° in males versus 54° ± 12° in females in one study [13], and 56.7° ± 14.7° in males vs 51.4° ± 13.1° in females in another [10].

Although back pain is common in AIS patients who are candidates for operative treatment [16], in our study, as in a previous one, there was no difference in back pain between males and females.

Previous studies that compared the results of brace treatment for AIS in male and matched female patients showed inferior results in the male patients [4,5]. This might explain the lower percentage of male patients who were managed with a brace to prevent progression of the curve.

Our results showed that in male patients who are candidates for surgical treatment there is a trend of lower thoracic flexibility compared with the female patients. These results are consistent with previous findings [8,9,11,15]. The greater rigidity of curves in male patients with AIS may contribute to the increased failure rate of brace treatment [4,5] and the less effective surgical correction [7,8].

LIMITATIONS

Our study has several limitations relating to its design, being a retrospective analysis of data that were collected prospectively. There is also the possibility that with a larger number of patients the trend of male lower thoracic flexibility compared with female patients would become statistically significant.

CONCLUSION

We were not able to demonstrate any clinical nor radiological statistical differences between male and female candidates for surgical treatment.

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References

1. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA. Adolescent idiopathic scoliosis. *Lancet* 2008; 371: 1527-37.
2. Ueno M, Takaso M, Nakazawa T, et al. A 5-year epidemiological study on the prevalence rate of idiopathic scoliosis in Tokyo: school screening of more than 250,000 children. *J Orthop Sci* 2011; 16: 1-6.
3. Nachemson A, Peterson L. Effectiveness of treatment with a brace in girls who have adolescent idiopathic scoliosis. A prospective, controlled study based on data from the Brace Study of the Scoliosis Research Society. *J Bone Joint Surg Am* 1995; 77: 815-22.
4. Weinstein SL, Dolan LA, Wright JG, Dobbs MB. Effects of bracing in adolescents with idiopathic scoliosis. *N Engl J Med* 2013; 369: 1512-21.
5. Karol LA. Effectiveness of bracing in male patients with idiopathic scoliosis. *Spine* 2001; 26: 2001-5.
6. Yrjonen T, Ylikoski M, Schlenzka D, et al. Results of brace treatment of adolescent idiopathic scoliosis in boys compared with girls: a retrospective study of 102 patients treated with the Boston brace. *Eur Spine J* 2007; 16: 393-7.
7. Sucato DJ, Hedequist D, Karol LA. Operative correction of adolescent idiopathic scoliosis in male patients. A radiographic and functional outcome comparison with female patients. *J Bone Joint Surg Am* 2004; 86-A: 2005-14.
8. Helenius I, Remes V, Yrjonen T, et al. Does gender affect outcome of surgery in adolescent idiopathic scoliosis? *Spine* 2005; 30: 462-7.

9. Marks M, Petcharaporn M, Betz RR, Clements D, Lenke L, Newton PO. Outcomes of surgical treatment in male versus female adolescent idiopathic scoliosis patients. *Spine* 2007; 32: 544-9.
10. Wang W, Zhu Z, Zhu F, et al. Different curve pattern and other radiographical characteristics in male and female patients with adolescent idiopathic scoliosis. *Spine* 2012; 37: 1586-92.
11. Kuklo TR, Lenke LG, Graham EJ, et al. Correlation of radiographic, clinical, and patient assessment of shoulder balance following fusion versus nonfusion of the proximal thoracic curve in adolescent idiopathic scoliosis. *Spine* 2002; 27: 2013-20.
12. Lenke LG, Betz RR, Harms J, et al. Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. *J Bone Joint Surg Am* 2001; 83: 1169-81.
13. Nevzorov R, Porter A, Mostov S, et al. Gender-related differences in outcomes of patients with cardiac resynchronization therapy. *IMAJ* 2018; 5: 311-15.
14. Wiser I, Scope A, Azriel D, Zloczower E, Carmel NN, Shalom A. Head and neck cutaneous squamous cell carcinoma clinicopathological risk factors according to age and gender: a population-based study. *IMAJ* 2016; 18: 275-8.
15. Sponseller PD, Flynn JM, Newton PO, et al. Harms Study Group. The association of patient characteristics and spinal curve parameters with Lenke classification types. *Spine* 2012; 37: 1138-41.
16. Smorgick Y, Mirovsky Y, Baker KC, Gelfer Y, Avisar E, Anekstein Y. Predictors of back pain in adolescent idiopathic scoliosis surgical candidates. *J Pediatr Orthop* 2013; 33: 289-92.

Capsule

Sensitive sensing

Neonatal care, particularly for premature babies, is complicated by the infants' fragility and by the need for a large number of tethered sensors to be attached to their tiny bodies. **Chung** and co-authors developed a pair of sensors that only require water to adhere to the skin and allow for untethered monitoring of key vital signs. On-board data processing allowed for efficient wireless near-field communication using standard protocols. The absence of cables makes it easier to handle the infants and allows for skin-to-skin contact between the babies and their parents or caregivers.

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Capsule

Making more youthful muscle

Aging reduces the body's ability to regenerate. The myogenic potential of muscle stem cells (MuSCs) is a prime example. Recent work shows that some factors that allow us to bounce back after injury include extracellular signals from the stem cell niche. **Lukjanenko** et al. show that MuSC dysfunction with aging is a result of the loss of matricellar WNT1 inducible signaling pathway protein 1 (WISP1) from fibro-adipogenic progenitors (FAPs). When WISP1 is secreted from FAPs, the Akt pathway is activated along with asymmetric MuSC cell division. Eliminating mouse WISP1 results in defective myogenesis with reduced MuSCs. By contrast, injecting aged mice with WISP1 rescues MuSC function. By identifying the cells and cell-secreted factors that support repair, it should be possible to generate more youthful muscle.

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Eitan Israeli

Capsule

Memory CD4+ T cells are generated in the human fetal intestine

The fetus is thought to be protected from exposure to foreign antigens, yet CD45RO+ T cells reside in the fetal intestine. Li et al. combined functional assays with mass cytometry, single-cell RNA sequencing and high-throughput T cell antigen receptor (TCR) sequencing to characterize the CD4+ T cell compartment in the human fetal intestine. The authors identified 22 CD4+ T cell clusters, including naive-like, regulatory-like and memory-like subpopulations, which were confirmed and further characterized at the transcriptional level. Memory-like CD4+ T cells had high expression of Ki-67, indicative of cell division, and CD5, a surrogate marker of TCR avidity, and produced the cytokines IFNγ and IL-2. Pathway analysis revealed a differentiation trajectory associated with cellular activation and pro-inflammatory effector functions, and TCR repertoire analysis indicated clonal expansions, distinct repertoire characteristics and interconnections between subpopulations of memory-like CD4+ T cells. Imaging mass cytometry indicated that memory-like CD4+ T cells co-localized with antigen-presenting cells. Collectively, these results provide evidence for the generation of memory-like CD4+ T cells in the human fetal intestine that is consistent with exposure to foreign antigens.

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