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CASE SERIES

Ponte osteotomies in a matched series of large AIS curves increase surgical risk without improving outcomes

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Abstract

Purpose The routine use of Ponte osteotomies in adolescent idiopathic scoliosis (AIS) surgery is controversial with conflicting data for coronal plane correction and little analysis in the sagittal plane. The objective of this study was to analyze the efficacy of Ponte osteotomies in large curve AIS.

Methods A single institution, prospectively-collected series of consecutive AIS patients who had Ponte osteotomies (P cohort) was directly matched to patients with no Pontes (NP cohort) by age, gender, Lenke classification, surgeon, coronal, and sagittal Cobb angles. The radiographic review included adjusted values using a 3D-derived published formula for preoperative T5-T12 kyphosis. Patient-reported outcomes (PROs) were assessed with the SRS-30 and Spinal Appearance Questionnaire (SAQ).

Results There were 68 patients (34/cohort) with minimum 2-year follow-up with no differences between P and NP cohorts in age, preoperative coronal Cobb (74.5° vs 70.8°), flexibility index, measured or 3D-adjusted T5-T12 kyphosis. Rod material/diameter, fusion levels, blood loss, and operative time did not differ, but implant density was higher in the P group (1.53 vs 1.31, $p < 0.001$). The P group had 7.9% greater coronal Cobb correction (66.6% vs 58.7%, $p < 0.003$) without difference in final Cobb angles (24.7° vs. 29.1°, $p = 0.052$). There were no differences in measured or adjusted T5-T12 kyphosis in the sagittal plane. The P group had a 15% rate of critical intraoperative neuromonitoring changes versus 0% in the NP group ($p = 0.053$). At follow-up, there were no differences in scoliometer measurements or any domain of SRS-30 or SAQ scores.

Conclusion In this first reported matched series of AIS patients, Ponte osteotomies provide small radiographic gains in the coronal plane with no improvement in the sagittal plane and no change in truncal rotation. There was a higher risk of critical intraoperative neuromonitoring changes, and no benefits in patient-reported outcomes. This calls into question the routine use of Ponte osteotomies in AIS, even for curves averaging 70 degrees.

Level of evidence II.

Keywords Adolescent idiopathic scoliosis · AIS · Ponte · Osteotomy · Posterior spinal fusion

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Introduction

Smith-Petersen originally introduced posterior column osteotomies of the spine to correct kyphosis from ankylosed segments in rheumatoid arthritis. This osteotomy through the superior and inferior articular processes in the lumbar spine provided deformity correction via leverage transmitted to the anterior column [1]. Alberto Ponte subsequently described a posterior column shortening osteotomy in the thoracic spine to correct Scheuermann's kyphosis. The "Ponte osteotomy" combines wide resection of the thoracic facet joints, laminae, and ligamentum flavum to generate a 5–10 mm posterior gap that closes with segmental instrumentation [2–5]. These osteotomies are widely utilized for correction of patients with primary hyperkyphosis in the sagittal plane [5–9] as they allow an estimated 1° of kyphosis correction for every 1 mm of resection, or approximately 10° of correction per level [9, 10].

Although Ponte osteotomies were initially intended to correct primary hyperkyphosis deformities this technique has been extended to treating adolescent idiopathic scoliosis (AIS) with the goal of improving the coronal and axial planes as well [11–15]. However, the routine use of Ponte osteotomies for standard AIS or even larger magnitude AIS cases remains controversial, with conflicting data as to the necessity, efficacy, and safety of this practice [16, 17]. The objective of this study was to analyze the efficacy of Ponte osteotomies to improve the correction of AIS curves.

Materials and methods

After Institutional Review Board approval, we queried our single-institution prospective database of patients with idiopathic scoliosis in whom posterior instrumented spinal fusion (PSF) had been performed. All families had prospectively consented to inclusion in the database. Surgeons recorded the use of an osteotomy at each level directly into our prospective database immediately following each surgical procedure.

Among consecutive PSFs performed from 2004 to 2015, we identified all patients with idiopathic scoliosis in whom ≥ 2 thoracic-level Ponte osteotomies had been performed for a primary PSF between ages 10 and 18 years old who had a minimum follow-up of 2 years. Radiographic inclusion criteria consisted of preoperative and > 2-years postoperative standing posteroanterior (PA) and lateral spine roentgenograms and preoperative supine side bending films. Patients were excluded for etiologies that were not strictly idiopathic, associated anterior surgery, three-column osteotomies, lumbar-level Ponte osteotomies, or any spine surgery other than PSF.

After identification of 34 consecutive patients who met these criteria with thoracic Ponte osteotomies (P cohort), we then performed a direct match (1:1 ratio) to patients in our prospective database who underwent PSF with No Ponte osteotomies (NP cohort). Strict matching criteria included age (± 1 year), gender, surgeon, Lenke classification, major coronal Cobb angle (± 5°), and T5-T12 sagittal Cobb angles (± 5°) (Fig. 1). We extracted data from our prospective database including patient demographics, fusion levels, implant type, implant density, estimated blood loss (EBL, by level, weight, and overall EBL), total surgical time, number of Ponte osteotomies performed, and intraoperative neuromonitoring (IONM) data. We then performed an additional retrospective chart review of each operative report, implant record, and follow-up documentation to verify prospectively collected data, surgical technique, and postoperative complications.

During the radiographic review, we measured coronal Cobb angles using standard technique via digital calipers. We then utilized the formula described by Parvaresh et al. to convert our 2-dimensional (2D) sagittal measurements into 3-dimensional (3D) adjusted values as an adjunct representation of true preoperative thoracic kyphosis: 18.1 ± (0.81 * 2D T5-T12 sagittal Cobb) – (0.54 * 2D coronal Cobb) [18]. We measured preoperative curvature stiffness on supine side-bending radiographs and then calculated the flexibility index of the thoracic curve (1–bending Cobb/standing Cobb angle). For Lenke 6 curves, we recorded both the thoracic and thoracolumbar/lumbar curves for comparison to the matched NP cohort. As we were interested in the results of thoracic level Ponte osteotomies, we used radiographic results in the thoracic spine for statistical analysis.

We utilized main thoracic scoliometer measurements and patient-reported outcome measures (PROs), including the Spinal Appearance Questionnaire (SAQ) and Scoliosis Research Society (SRS)-30 scores, which had been recorded in our prospective database preoperatively and at 1- and 2-year follow-up. We included all SRS-30 domains to evaluate clinical outcomes: activity, appearance, mental, satisfaction, pain, and total score.

Statistical significance was set at a *p*-value of < 0.05. Variables in each cohort were compared using the two-sample t-test. Nonparametric data were compared with the Mann–Whitney *U*-test.

Results

There were 68 patients in the study, with 34 in both the P and NP groups, including 26 females (76%) and 8 males (24%) in each group. There were no differences identified between the P and NP cohorts in age, body mass index (BMI), or length of follow-up (Table 1a). The Lenke classification was type 1 in 29% and type 2 in 50% (Table 2). All thoracic curves were right-sided. Due to the strict matching protocol, there were no differences between the P and NP groups in preoperative major thoracic coronal Cobb angles (74.5° vs. 70.8°), T5-T12 kyphosis (28.0° vs. 27.6°), or 3D adjusted T5-T12 kyphosis (0.4° vs. 2.2°). There also was no difference between groups in preoperative thoracic curve stiffness as measured by the flexibility index (40% vs. 39%) (Table 1b).

The mean number of thoracic Ponte osteotomies performed at the apex of the thoracic curve was 3.5 (range 2–9). Implant density was significantly higher in the P group (1.53 vs. 1.31 implants/level, $p < 0.001$), but there were no statistically significant differences between the P and NP groups in the number of fusion levels, total operative time, or EBL

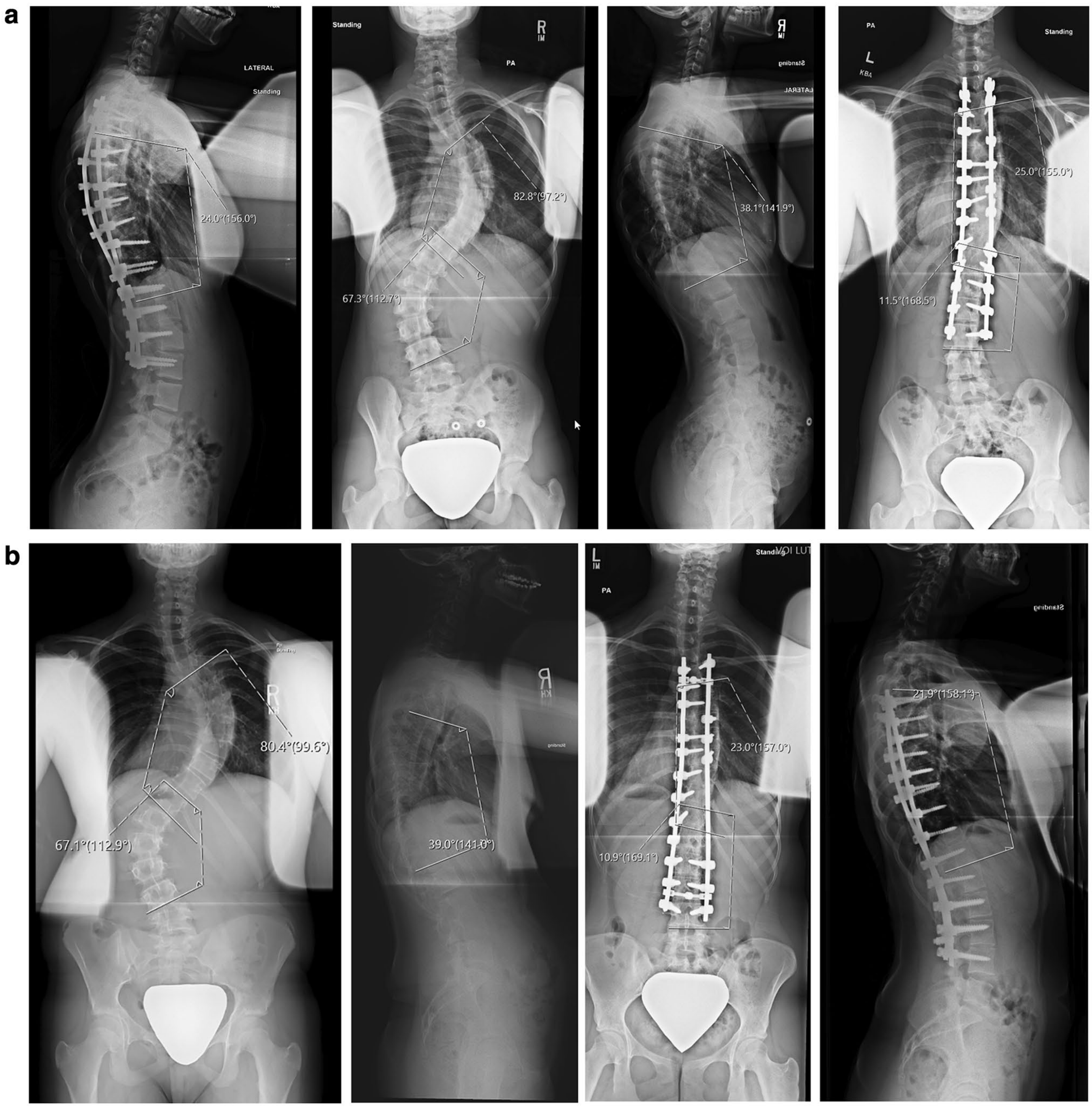

Fig. 1 Matched patients in the Ponte (**a**) and No Ponte (**b**) groups. **a** Ponte group. 13-year-old female with a Lenke 3C curvature with 83° main thoracic (MT) and 67° thoracolumbar/lumbar (TL/L) with 38° thoracic kyphosis, adjusted kyphosis 26°, underwent posterior fusion and instrumentation from T3 to L3 with 2-year correction of 25° MT, 12° TL/L and 24° kyphosis, adjusted kyphosis of 26°. **b** No Ponte group. 13-year-old female with a 80° MT and 67° TL/L curve with 39° kyphosis, adjusted kyphosis of 9°, underwent posterior fusion and instrumentation from T4 to L4 with 2-year correction to 23°MT and 11°TL/L with 22°kyphosis, adjusted kyphosis of 22°

(Table 1c). Additionally, no difference was seen in the average diameter of the left or right rod (Table 1c), or when analyzing the distribution of rod diameters between groups, nor in type of implant used (Table 3).

In the coronal plane at final follow-up, the P group had 7.9% greater coronal Cobb correction (66.6% vs. 58.7%, $p=0.003$) resulting in a 4.4° smaller residual thoracic Cobb angle (24.7° vs. 29.1°, $p=0.052$). In the sagittal plane there were no differences between the P and NP cohorts in final T5-T12 sagittal Cobb angle, or in the change in T5-T12 sagittal Cobb angle using both the adjusted and non-adjusted values (Table 1d).

Table 1 Comparison of Ponte vs. No Ponte Matched Control for demographics: Mean Value ± Standard Deviation

	Ponte ($N=34$)	No Ponte ($N=34$)	p-value
(a) Age at Surgery (years)	14.6 ± 2.3	14.8 ± 2.0	0.695
BMI (kg/m^2)	21.4 ± 3.1	20.7 ± 4.8	0.075
Follow-up (months)	36.1 ± 1.6	40.7 ± 1.4	0.099
(b) Preoperative radiographs			
Thoracic Coronal Cobb (degrees)	74.5 ± 15.2	70.8 ± 13.4	0.341
Flexibility index (1-bending Cobb angle/standing Cobb angle)*100 (%)	39.6 ± 12.7	39.1 ± 10.6	0.932
T5-T12 Kyphosis (degrees)	28.0 ± 16.0	27.6 ± 14.5	0.854
[a]Adjusted T5-T12 Kyphosis (degrees)	0.4 ± 13.5	2.2 ± 12.4	0.540
(c) Perioperative variables			
Fusion Levels	11.5 ± 1.8	11.4 ± 1.7	0.855
ImplantDensity	1.53 ± 0.25	1.31 ± 0.24	**< 0.001**
Leftdiameter (mm)	5.8 ± 0.4	5.9 ± 0.4	0.445
Rightdiameter (mm)	5.7 ± 0.4	5.6 ± 0.6	0.640
Total EBL (cc)	825.0 ± 511.1	861.2 ± 583.4	0.825
EBL Level (cc/# levels fused)	70.0 ± 37.7	73.8 ± 45.3	0.773
EBL Weight (cc/kg)	15.5 ± 10.7	16.8 ± 10.8	0.548
TotalSurgicalTime (min)	296 ± 64	286.3 ± 63.8	0.526
Length of Hospital Stay (days)	4.4 ± 1.0	4.6 ± 1.4	0.815
(d) Postoperative radiographs (2 years)			
Thoracic Coronal Cobb (degrees)	24.7 ± 11.2	29.1 ± 8.6	0.052
Change of Coronal Cobb (Pre-Post) (degrees)	49.8 ± 15.4	41.7 ± 11.5	**0.022**
Coronal Correction Index (1-Post/Pre)*100 (%)	66.6 ± 14.1	58.7 ± 10.3	**0.003**
T5-T12 Kyphosis (degrees)	22.6 ± 8.9	24.6 ± 9.7	0.351
Change of Kyphosis T5-T12 (Pre-Post) (degrees)	5.5 ± 14.0	3.0 ± 12.1	0.556
[a]Adjusted T5-T12 Kyphosis (degrees)	22.7 ± 8.9	24.7 ± 9.7	0.351
Change of [a]Adjusted Kyphosis T5-T12 (Pre-Post) (degrees)	−22.1 ± 12.2	−22.5 ± 11.0	0.971

[a]Adjusted kyphosis to predict true 3D kyphosis utilizing the formula described by Parvaresh et al. [18]

Table 2 Patients in the Ponte group ($N=34$) were strictly matched to patients with No Pontes ($N=34$) by Lenke classification, including lumbar modifier

	$N=68$		$N=$	%
Lenke classification				
Lenke 1	**20**			**29.4**
		1A	12	17.6
		1B	10	11.8
		1C	0	0.0%
Lenke 2	**34**			**50.0**
		2A	26	38.2
		2B	4	5.9
		2C	2	2.9
Lenke 3	**8**			**11.8**
		3C	8	11.8
Lenke 4	**0**		0	**0.0**
Lenke 5	**0**		0	**0.0**
Lenke 6	**6**			**8.8**
		6C	6	8.8

Table 3 Comparison of type of implant in the Ponte and No Ponte groups

	Ponte ($N=34$ patients)		No Ponte ($N=34$ patients)		p value
	$N=$	%	$N=$	%	
Implant type					
Left rod implant type					0.505
Cobalt Chrome	11	32.4	15	44.1	
Cobalt Chrome Plus	8	23.5	9	26.5	
Stainless Steel	14	41.2	10	29.4	
Titanium	1	2.9%	0	0	
Right rod implant type					0.159
Cobalt chrome	10	29.4	19	55.9	
Cobalt chrome plus	5	14.7	2	5.9	
Stainless steel	14	41.2	10	29.4	
Titanium	5	14.7%	3	8.8	

All patients had IONM with transcranial motor evoked potentials (TcMEPs) and somatosensory evoked potentials (SSEPs). There were a greater number of critical IONM changes in the P group with 5 of 34 (14.7%) having alerts compared to none of the 34 (0%) in the NP group ($p=0.053$). One patient in the P group had loss of signals during wound closure and exploration revealed spinal cord compression by bone graft at the Ponte osteotomy site, which was removed and the IONM returned to baseline. Another patient had loss of signals while performing Ponte osteotomies that was attributed to vasovagal response secondary to an instrument near/against the cord. Her surgery was aborted and she emerged from anesthesia neurologically intact, and the surgery was completed without issues the following day with attempts at full correction. A third patient had decreased amplitude of SSEPs during the Ponte osteotomies, and loss of MEPs and SSEPs during deformity correction, so the surgery was completed with less deformity correction. The IONM changes in two additional patients were attributed to deformity correction, so the surgeries were completed with less deformity correction. All patients awakened neurologically intact after the appropriate intervention had occurred.

As three patients with IONM critical changes had notations in the operative report that surgery was completed with deliberately less deformity correction, we excluded these three patients and their matched controls and re-analyzed deformity correction. In reanalysis of these data excluding these instances, the same trends persisted, with improved coronal correction in the Ponte group over the controls (66.9% vs. 59.1%, $p=0.005$). Coronal Cobb angles in the Ponte group decreased from 73.1° to 24.0° at follow-up, versus 69.4° reduced to 28.3° at follow-up in the control group, for a 4.3° residual difference ($p=0.026$). There was no difference in T5-T12 kyphosis at final follow-up (22.3° vs. 23.9°, $p=0.412$). In addition to IONM changes, complications requiring reoperation occurred in 6 patients in the P group (17.6%) vs. 2 patients in the NP group (5.9%) ($p=0.259$). These complications were evenly divided in both groups into those with implant failure/prominence (50%) and surgical site infection (50%) (Table 4). No additional complications were identified.

There were no significant differences in main thoracic scoliometer measurements between the P and NP groups preoperatively or at 1- or 2-year follow-up (Table 5). Furthermore, there were no significant differences in SAQ or SRS-30 scores preoperatively or at 2-year follow-up, nor in score changes between those time periods (including all SRS-30 domains) (Table 6).

Table 4 Complications encountered during and after surgery in the Ponte and No Ponte groups

	Ponte		No Ponte		*p*-value
	N=	%	*N*=	%	
Complications					
IONM critical change	**5**	**14.7%**	**0**	**0**	**0.053**
Reoperations	**6**	**17.6%**	**2**	**5.9%**	0.259
Implant failure	1		1		
Prominent Implants	2				
Surgical Site Infection	3		1		
Acute	1				
Delayed	2		1		
Total	**11**	**32.4%**	**2**	**5.9%**	**0.012**

Table 5 Comparison of scoliometer measurements between the Ponte and No Ponte groups at the preoperative and 2-year postoperative visits

	Ponte ($N=27$)	No Ponte ($N=31$)	*p*-value
Scoliometer measurements (2 years)			
Scoliometer: pre-op	19.3 ± 5.8	19.0 ± 5.5	0.758
Scoliometer: 2 year	13.3 ± 6.6	13.8 ± 4.9	0.667
Change in Scoliometer: 2 year—pre-op	−6 ± 6	−5.55 ± 4.7	0.963

Discussion

In a closely matched group of idiopathic scoliosis patients, apical Ponte osteotomies during PSF for large magnitude curves (mean > 70 degrees) improve coronal plane correction (66.6% vs. 58.7%, $p=0.003$) but do not significantly alter the sagittal plane, rib prominence, or patient-reported outcomes (all SAQ and SRS score domains). This small coronal plane improvement with no sagittal plane improvement is then weighted against the increased incidence of critical intraoperative neuromonitoring changes associated with Ponte osteotomies, which we found to be 14.7% vs 0%.

Ponte osteotomies were initially intended to reduce kyphosis by shortening the posterior column, but when Shufflebarger et al. first described the posterior approach for lumbar and thoracolumbar AIS, they incorporated this technique to improve flexibility in both the coronal and sagittal planes [11, 12]. Posterior column shortening resulted in increased lumbar lordosis with improvement in lumbar deformity correction via a posterior-only approach.

Subsequent authors expanded the application of Ponte osteotomies for restoring kyphosis in hypokyphotic thoracic scoliosis by lengthening the posterior column, while

Table 6 Comparison of SRS-30 measurements between the Ponte and No Ponte groups at the preoperative and 2-year postoperative visits, and the change between the two groups (Δ) in the 2-year time interval following surgery

	Ponte ($N=29$)	Non-Ponte ($N=27$)	p-value
SRS-30 Scores			
Satisfaction			
Pre-op	3.6	3.4	0.656
2 year	4.5	4.6	0.274
Δ	0.9	1.1	0.319
Appearance			
Pre-op	3.1	3.2	0.849
2 year	4.2	4.2	0.884
Δ	1.1	1	0.617
Pain			
Pre-op	4.0	4.1	0.359
2 year	4.3	4.5	0.131
Δ	0.35	0.3	0.796
Mental			
Pre-op	4	4	0.916
2 year	4.3	4.3	0.662
Δ	0.3	0.4	0.814
Activity			
Pre-op	4	4.2	0.114
2 year	4.2	4.4	0.182
Δ	0.2	0.3	0.777
Total Score			
Pre-op	3.8	3.8	0.423
2 year	4.2	4.3	0.410
Δ	0.4	0.4	0.674

also improving coronal plane correction. In a single-cohort multicenter study reporting the results of Ponte osteotomies with pedicle screw instrumentation in AIS, 87 consecutive patients with a mean 57° major thoracic curves demonstrated an overall 64.9% coronal plane correction, with 8% IONM critical changes. With no comparison group of patients without Ponte osteotomies, the authors acknowledged that they could not definitively isolate the variables in surgical technique that influenced outcomes, including Ponte osteotomies [14]. Samdani and colleagues utilized a multicenter prospective database to compare 125 patients with Ponte osteotomies to 66 unmatched controls without Ponte osteotomies in AIS [15]. Patients with Ponte osteotomies achieved coronal plane correction from 51.5° to 16.8°, while the control group corrected from 50.8° to 19.4°. Thus, their correction indices were 67.1% versus 61.8% (a 3.3° coronal plane difference) in these relatively small preoperative curves. Similar to our findings, this mild improvement in the Ponte osteotomy cohort was not associated with improved SRS scores. Their Ponte osteotomy cohort experienced higher EBL, possibly due to their statistically significant association of longer fusions in the Ponte osteotomy cohort compared to the unmatched controls [15]. From these two studies, it appears that coronal plane correction with Ponte osteotomies is 65%, which is similar to the correction we report in the Ponte group but with larger preoperative curves while the correction without Ponte osteotomies is 60%.

Conversely, Halanski and Cassidy reviewed another unmatched comparison of AIS patients with and without Ponte osteotomies, and they found no significant difference in coronal (84% versus 83%) or sagittal plane correction (28° versus 25° final) [16]. The coronal Cobb angles decreased from 59° to 9° in the Ponte group versus 52° to 9° in the non-Ponte group, while EBL was 33 ml/level higher and the operative time was 8 min/level longer in the Ponte group. They concluded that although Ponte osteotomies may help correct extremely stiff curves or kyphoscoliosis, they should not be used regularly during routine surgery for low-grade AIS [16].

Biomechanical studies contribute to the controversy regarding the efficacy of Ponte osteotomies on spinal flexibility. Wiemann et al. [19] concluded that Ponte osteotomies in instrumented adult cadavers reduced the axial-plane force required to rotate the vertebral body by 18% compared to vertebrae with intact facet joints. Likewise, Sangiorgio et al. [20] concluded that sequential Ponte osteotomies in 5 adult cadavers improved flexion (+1.6°/osteotomy), extension (+1.5°/osteotomy), and axial rotation (+2.8°/osteotomy) with little effect on lateral bending motion. However, neither of these studies tested the effects of inferior facetectomies alone compared to specimens with intact facet joints or those with Ponte osteotomies [19, 20]. Wang et al. [21] concluded that a Ponte osteotomy produces more flexibility than an inferior facetectomy in the axial and sagittal plane, but it has no effect on coronal correction, and overall gains are far less effective than anterior releases. In contrast, Holewijn et al. [17] found 29.6% improvement in flexion and axial rotation after resection of the interspinous ligament, inferior facets, and ligamentum flavum, but sequential superior facetectomy provided no biomechanical benefit, thereby demonstrating the "law of diminishing returns"[17].

Our study did not detect significant differences in EBL or operative time (10 min shorter in the Ponte osteotomy group, $p=0.526$). These findings were unexpected as prior studies have found that Ponte osteotomies increase both operative time [16] and EBL[14, 15]. We do not have an explanation for this finding, especially because our study cohorts had similar total fusion levels and a higher implant density in the Ponte osteotomy group, surgical technique or blood loss recording method.

Although no postoperative neurologic deficits were present in our study, the increase in critical intraoperative changes in the Ponte osteotomy group highlights the risk associated with purposefully entering into the spinal canal. We report a 14% incidence of IONM changes in the Ponte group which is consistent with higher rates in these patients especially when combined with the other risk factor of patients having larger curves- both previously reported in the literature [22]. This is especially apparent in the patient who was found to have bone graft compressing the spinal cord at the Ponte osteotomy site during wound closure. Without appropriate neuromonitoring until the end of wound closure and due diligence, this easily could have resulted in a post-operative neurologic deficit.

There are limitations inherent to this study. First, although data were collected prospectively, this retrospective review includes multiple surgeons with different surgical techniques and the number of osteotomies performed for each patient is varied and was at the discretion of the surgeons. We have reviewed the surgical technique for each of the surgeons and the technique follows that of Ponte in his original description and therefore significant variation should be minimized. We did match our control group by surgeon but it is not possible to distinguish why each surgeon did or did not indicate similar patients for Ponte osteotomies. We believe the decisions are related to changing trends and anecdotal experience over time. Second, a larger sample size may identify meaningful radiographic or clinical findings that our study failed to detect. The study was done over a long period of time to acquire enough cases as the philosophy of the institution has been to use the Ponte osteotomy for larger AIS curves and is reflected in the average curve being 70 degrees. There is no bias with respect to when the patients had their Ponte osteotomies as the two groups time to follow-up from their operative procedures were the same. Third, we do not have true 3D-imaging measurements but tried to account for this by predicting 3D deformity in the sagittal plane with two-dimensional variables using a previously described formula [18]. We included scoliometer measurements of truncal rotation assessment as an adjunct representation of vertebral body rotation. Scoliometer measurements correlate with apical vertebral rotation preoperatively but overestimate vertebral rotation postoperatively due to fixed deformation of the ribs that cannot be entirely corrected despite improved vertebral rotation [23]. Fourth, this study analyzes the effect of the Ponte osteotomy only on the main thoracic curve without any data analysis on the effect of the osteotomy on the proximal thoracic curve or thoracolumbar/lumbar curves. Fifth, deformity correction is dependent on the implants utilized especially the size and metal type of rods used. We could not demonstrate a difference between these parameters between groups for the left correcting rod or the right rod. Although less so, the type of pedicle screw may also influence deformity correction and this was not specifically studied. Finally, three of the patients in the Ponte group had less intended deformity correction secondary to IONM changes and this may have affected the overall average correction in this group.

This is the first study evaluating the use of Ponte osteotomies with comparison to a strictly matched cohort. Rigid matching criteria were a notable strength of this study, including age, gender, surgeon, Lenke classification, major coronal Cobb angle, and T5-T12 sagittal Cobb angles. Our data demonstrate that among similar idiopathic thoracic curves averaging 70 degrees, Ponte osteotomies yield 7.9% improvement in the coronal plane but no radiographic benefit in the sagittal plane, or axial plane correction per scoliometer measurements. Most importantly, perhaps, is there were no detectable patient-reported outcome benefits as reflected by SRS and SAQ scores.

With increased attention to the sagittal plane and restoring kyphosis in AIS in the setting of thoracic hypokyphosis, it is a growing trend at some centers to perform routine Ponte osteotomies to increase posterior distraction and thoracic kyphosis [11–15]. However, this study reveals no improvement in the sagittal plane, no change in truncal rotation, small improvements in the coronal plane, a higher risk of critical intraoperative neuromonitoring changes, and no benefits in patient-reported outcomes. The greater use of pedicle screws and perhaps, more importantly, stronger stiffer rods may obviate the need for routine Ponte osteotomies to improve the coronal plane and restore thoracic kyphosis. These data call into question the routine use of Ponte osteotomies in AIS even for curves averaging 70 degrees.

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Declarations

Conflict of interest LF (none), KP (none), DG (none), DS (Globus, Royalties, outside of submitted work).

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