Do Multilevel Ponte Osteotomies in Thoracic Idiopathic Scoliosis Surgery Improve Curve Correction and Restore Thoracic Kyphosis?

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Background: To compare the routine use of posterior-based (Ponte) osteotomies to complete inferior facetectomies in thoracic idiopathic scoliosis. Hypokyphosis is common in thoracic adolescent idiopathic scoliosis. The use of pedicle screw fixation in deformity correction can exacerbate this hypokyphosis. We hypothesized that by utilizing posterior-based Ponte osteotomies rather than facetectomies, we could improve coronal plane correction and decrease the loss of kyphosis during curve correction.

Methods: The radiographs and clinical charts of patients with idiopathic scoliosis (Lenke types I, II) who underwent isolated thoracic posterior spinal fusion utilizing primarily pedicle screw constructs from January 2008 to August 2010 were reviewed. Maximum preoperative Cobb angle, thoracic kyphosis (T5-T12), levels instrumented, number of posterior-based osteotomies, operative time, estimated blood loss, and postoperative residual coronal Cobb angle and kyphosis were recorded. Operative time per level, blood loss per level, percent main curve correction, and change in thoracic kyphosis was calculated. Patients having undergone complete inferior facetectomies and those with multilevel Ponte osteotomies were then compared.

Results: Eighteen patients underwent posterior spinal fusion with osteotomies and 19 patients had complete inferior facetectomies during this time period. The osteotomy cohort had a larger preoperative Cobb angle [59 ± 10 vs. 52 ± 8 (mean $\pm$ SD); $P = 0.03$]. No difference was observed in the preoperative kyphosis (22 ± 15 vs. 25 ± 12) or in levels fused (9 ± 1 vs. 8 ± 1). Patients with routine osteotomies had them performed at 76% of the levels instrumented. No significant difference was found in terms of percentage of coronal plane correction (84% in both groups), average postoperative kyphosis 28 ± 8 versus 25 ± 7, or the change in kyphosis 6 ± 14 versus 0 ± 2 degrees, in the osteotomy and the facetectomy groups, respectively. Estimated blood loss per level was significantly higher in the osteotomy group (97 ± 42 mL vs. 66 ± 25 mL; $P = 0.01$) as was time per level 31 ± 5 versus 23 ± 3 minutes/level ($P < 0.001$).

Conclusions: This study shows a significantly higher blood loss and operative time associated with the use of routine posterior osteotomies in the thoracic spine without a significant improvement in coronal or sagittal correction.

Keywords: scoliosis, deformity, Ponte, osteotomy, facetectomy

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The spinal deformity in adolescent idiopathic scoliosis (AIS) is a complex 3 dimensional deformity including curvatures in the coronal plane associated with rotational deformities in the axial plane. When these deformities occur in the thoracic spine, they are often lordotic or hypokyphotic in nature.[1–3] These surgical interventions are among some of the most difficult faced in pediatric orthopedics.

As time and experience in treating these deformities has progressed, instrumentation of these deformities to correct the deformity and prevent progression has evolved. Recently, posterior placed pedicle screw fixation has been the instrumentation method of choice in treating these deformities.[1–3] The benefits of this technique include increased correction, segmental fixation, resulting in increased "posterior only" surgery, and decreased number of levels requiring fusion. Although this technique is very powerful in correcting coronal plane deformities,[4] an exacerbation of the hypokyphosis after curve correction has been noted.[2,5,6] The long-term effects of these sagittal plane deformities are unknown.

Various osteotomies have been used in spinal deformity surgery to help restore normal alignment. All of these osteotomies help to mobilize the spinal column. Ponte osteotomies[7] have been shown to be useful in possibly decreasing the levels of fusion in lumbar deformities[8] and in decreasing the kyphosis in hyperkyphotic deformities.[7] These osteotomies involve removing bone posteriorly including both superior and inferior facets including the ligamentum flavum, at each level.[8]

In this study we wanted to explore the benefit of performing routine Ponte osteotomies rather than standard inferior facetectomies throughout the thoracic spine during AIS surgery. We hypothesized that routine use of Ponte osteotomies would be associated with greater coronal plane curve correction and less loss of kyphosis, but would require more operative time and blood loss.

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METHODS

A retrospective review of the radiographs and clinical charts of patients with idiopathic scoliosis (Lenke types I, II) who underwent isolated thoracic posterior spinal fusion utilizing primarily pedicle screw constructs from January 2008 to August 2010 at a single institution were reviewed after appropriate Institutional Review Board approval. "Isolated" thoracic fusion was limited to those instrumented to L1 and above. Patients with kyphoscoliosis, that is, those with >45 degrees of kyphosis from T5 to T12, were not included in this review as our purpose was to see if kyphosis could be maintained or induced using these techniques. Earlier in the study period, we had performed osteotomies on all patients undergoing posterior spinal fusion with instrumentation. Later in the study period, we switched to facetectomies as we did not feel that the additional operative time and blood loss associated with the osteotomies were benefiting our patients.

Patients were placed prone on an Jackson spinal table. A standard posterior approach was made to the spine. Electrocautery was used for hemostasis. Dissection and exposure were performed in a subperiosteal manner. Simultaneous bilateral exposure was the norm in these patients. Over the study period we did progress into a stepwise approach to simultaneous bilateral pedicle screw insertion with the 2 surgeons working at different levels. Ponte osteotomies were performed by first removing the inferior facet from the superior vertebra. After this, the epidural space was opened using a rongeur and the entire ligamentum flavum and superior facet from the inferior vertebra were removed, thus all posterior bony and ligamentous attachment between levels were resected. In general, all patients received an epidural catheter for postoperative pain. Occasionally, these children also received intrathecal morphine for pain. Drains were not routinely used postoperatively. In general, the largest and stiffest implants that the surgeon felt appropriate for a given patient's habitus were utilized. Earlier in the study ultra-high strength stainless steel was used and later cobalt chrome. Uniplanar screws were almost exclusively used in all these patients.

Maximum preoperative Cobb angle, thoracic kyphosis (T5-T12), bending flexibility of largest curve, defined as $1-$(bending Cobb angle/standing Cobb angle), number of levels instrumented, number of posterior-based osteotomies, operative time, and estimated blood loss were recorded using clinical records and radiographs. Postoperative residual coronal Cobb angle and kyphosis were primarily recorded using 6-week to 4-month postoperative radiographs. All radiographs were measured by a single surgeon (M.A.H.). Operative time per level, blood loss per level, percent main curve correction, and change in thoracic kyphosis were calculated. Patients having undergone complete inferior facetectomies and those with multilevel Ponte osteotomies were then compared. In addition to operative time, blood loss, and biplanar curve correction, a review of the patients' charts for complications was also performed.

RESULTS

Thirty-five patients met the inclusion criteria for this review. Eighteen patients underwent posterior spinal fusion with osteotomies and 17 patients had complete inferior facetectomies during this time period. The osteotomy cohort had a slightly larger preoperative Cobb angle [59 ± 11 vs. 52 ± 8 (mean $\pm$ SD); $P = 0.04$]. No difference was observed in the preoperative kyphosis (20 ± 14 vs. 24 ± 12), flexibility in curves ($33 \pm 19\%$ vs. $41+/16\%$), or in levels fused (9 ± 1 vs. 8 ± 1).

Patients in the osteotomy cohort had the osteotomies performed at 75% of the levels instrumented. One single level osteotomy was performed in the facetectomy group. No significant difference was found in terms of percentage of coronal plane correction (84% vs. 83%), average postoperative kyphosis 28 ± 8 versus 25 ± 7, or the change in kyphosis 8 ± 11 versus 1 ± 10 degrees, in osteotomy and the facetectomy groups, respectively. Estimated blood loss per level was significantly higher in the osteotomy group (97 ± 42 mL vs. 66 ± 25 mL; $P = 0.01$) as was time per level 31 ± 5 versus 23 ± 3 minutes/level ($P < 0.001$) (Table 1).

Serious complications in this study were low in both groups. Each group had several patients with subjective sensory changes, the majority of which were transient. The use of postoperative epidural analgesia confuses this comparison while reviewing the charts in a retrospective manner, and none had any permanent motor deficits. One patient in the osteotomy group had a postoperative pneumothorax, whereas 1 patient in the facetectomy group needed an upper screw removed at a second operative setting.

DISCUSSION

Deformity correction utilizing pedicle screw constructs is an extremely powerful technique in correcting coronal plane deformities in AIS. Although multisegment derotation maneuvers decrease the rib hump and axial plane deformities, these techniques may further exacerbate the loss of kyphosis in the sagittal plane.[9] As our understanding of this deformity has continued to improve and our experience with these devices has grown, problems such as decompensation[10] and sagittal plane abnormalities have arisen.[2,3,6]

Multiple techniques to decrease the loss of thoracic kyphosis associated with coronal plane curve correction have been explored. Posterior distraction during concave curve correction is a kyphosis inducing correction maneuver that can be used. Performing simultaneous rod rotation during correction appears to aid in this as well.[1] Utilizing a large diameter stiff rod in addition to segmental pedicle screws has also been advocated.[11] In the current study, we combine routine use of large stiff rod (¼ inch in most cases with either high strength stainless steel or cobalt chrome), segmental fixation (pedicle screws at every level if safely obtainable), and routine posterior releases through the Ponte osteotomies. It was our reasoning that by removing all possible osseous impingement and the ligamentum flavum between each level, we would

TABLE 1. Comparison Between Osteotomy and Facetectomy Cohorts

	Osteotomy	Facetectomy	*P*
Preoperative			
Age	13.2 ± 3	13.7 ± 2	0.6
Sex (M/F)	(5/12)	(2/16)	0.2
Preoperative Cobb (degrees largest curve)	59 ± 10	52 ± 8	0.04
Preoperative Cobb flexibility (1-Cobb bending/Cobb standing)	33 ± 19	41 ± 16	0.2
Preoperative sagittal kyphosis (degrees T5-T12)	20 ± 15	24 ± 12	0.4
Surgical paramenters			
Levels	9 ± 1	8 ± 1	0.2
operating room time/level	31 ± 5	23 ± 2	< 0.001
Estimated blood loss/level	99 ± 43	66 ± 25	0.01
Postoperative			
Largest postoperative residual Cobb	9 ± 6	9 ± 4	0.8
Percentage of Cobb improvement	84 ± 9	83 ± 6	0.7
Postoperative sagittal Cobb	28 ± 8	25 ± 7	0.2
Change in sagittal Cobb	8 ± 11	1 ± 10	0.3

observe superior curve correction and that we would be able to induce more kyphosis with these stiff rods. However, after reviewing our results, this does not appear to be the case. Both groups had a rather normal T5-T12 kyphosis before and after correction. The routine additional release appears to have had very little effect on the deformity correction in either plane.

More important than ultimate curve correction is patient safety. Significant operative time (often > 6–8 h), blood loss (500–2500 mL),[12–17] and complications[18–21] have been reported in scoliosis surgery. We attempted to minimize any negative effects of increased operating room time and blood loss that from the osteotomies might have had by using the services of 2 fellowship trained pediatric spinal deformity surgeons (M.A.H. and J.A.C.) on all of these cases. Complications were low in both groups. From this study it appears that the routine use of these osteotomies does not significantly improve curve correction in the thoracic spine, but does lead to increased operative time and blood loss. We would like to note that despite this, under certain circumstances such as an extremely stiff curve or kyphoscoliotic deformity, these osteotomies may prove to be very useful.

The weakness of this study is its retrospective nature, the relatively small numbers, and short follow-up. As these patients were not randomized, the osteotomy group was operated on earlier in the study period, and our technique of utilizing 2 surgeons during these cases continued to improve in the study period, thus this may be a confounding variable. Similarly there was a potential for differences in rod stiffness as many of the children undergoing the osteotomy had the stiffest ¼ inch stainless-steel rods available at that time and many in the facetectomy group had ¼ inch cobalt-chrome rods. The cobalt-chrome rods became available later during the study period and the decision was made to switch. The short term follow-up of these patients might be viewed as a weakness, but the duration of follow-up was sufficient to answer the primary outcome of interest, "Do multilevel Ponte osteotomies improve the deformity correction in the coronal and sagittal plane?" We believe our endpoints allowed us to answer that question. The relatively small sample size may have caused this study to be slightly underpowered to find a statistical difference in deformity correction. However, with these same small numbers, we were able to show significant differences in terms of operative time and blood loss. Without seeing a statistical difference in deformity correction, we doubt a clinically relevant difference would be found that had more patients included into each arm. We do not feel it ethically responsible to continue to routinely perform these osteotomies on every child with thoracic scoliosis. Despite these weaknesses, this is the first study to look at the use of routine posterior osteotomies, combined with relatively stiff rods, and pedicle screw fixation to improve both coronal and sagittal plane deformity. These cohorts were very uniform and all were operated on using the same technique by the same 2 surgeons working in tandem.

On the basis of the results of this study, there does not appear to be any benefit to curve correction while utilizing Ponte osteotomies compared with facetectomies. Taking into consideration the increased blood loss and operative time, the authors have discontinued the routine use of these osteotomies. Although we cannot recommend the routine use of multilevel Ponte osteotomies in thoracic scoliosis patients, the benefit in individual patients should be weighed against the presented risks.

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