

Minimally Invasive Surgery for AIS: An Early Prospective Comparison with Standard Open Posterior Surgery

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Abstract

Study design: Prospective matched-control comparison study.

Objective: To prospectively compare deformity correction and measures of perioperative morbidity between minimally invasive posterior spinal fusion and conventional open posterior procedures in age- and curve classification-matched individuals.

Summary of background data: Minimally invasive surgery (MIS) has evolved in an effort to decrease the rate of approach-related morbidity associated with conventional open procedures for spinal disorders. Its widespread use in spinal trauma and degenerative disorders has yielded similar clinical results to open techniques with the added benefit of optimizing peri-operative morbidity. No report has been made comparing the clinical results of MIS to conventional open procedures in the setting of adolescent idiopathic scoliosis (AIS).

Methods: Patients enrolled in a multi-center, longitudinal, prospective AIS study were included in this analysis. Pre-op, peri-op and first erect post-op data was evaluated. 16 MIS patients were matched for age, sex, Lenke classification, and curve size with 16 conventional open posterior procedures. All cases were also matched to a single surgeon to reduce potential surgeon-induced variability. Statistical analysis was done using SPSS v.18.

Results: Age, gender, Lenke classification and curve magnitude were not statistically different between individuals treated with MIS or open surgery (Table 1). Post-op major Cobb was 20 degrees (curve correction 63%) in those treated with MIS and 18 degrees (curve correction 68%) in those treated with open surgery. Both estimated blood loss and length of stay (LOS) were significantly less in the MIS group (277 mL, 4.63 days) compared to the open group (388 mL, 6.19 days); however OR time was significantly longer in the MIS group (444 min) compared to the open group (350 min).

Conclusions: MIS for AIS has similar results to standard open posterior techniques, specifically for curve correction. Although increase in operative time was noted in the MIS group, advantages of MIS over standard open procedures seem to include decreased LOS and blood loss. Further follow-up will be critical to evaluating the longer-term outcomes of the MIS approach to AIS treatment.

Keywords: Spinal deformity; Adolescent idiopathic scoliosis; AIS; Minimally invasive; Surgery; MIS; Posterior spinal fusion

Introduction

Conventional open spine procedures are often associated with significant peri-operative morbidity [1-5]. In an effort to decrease this approach-related morbidity, minimally invasive surgery (MIS) in spine has been gaining increasing popularity [1,6-12]. Many authors have reported encouraging results of MIS in adult patients leading to its widespread use in the setting of adult spinal trauma and degenerative conditions [1,2,11,13-16].

Commonly, standard open posterior procedures for spinal deformity are associated with significant soft tissue disruption, blood loss, post-operative pain, and prolonged recovery. MIS in deformity may have the potential to significantly impact the approach-related morbidity of standard open procedures; however, it is not yet widely recognized in deformity application. Although its purported advantages may have great potential in spinal deformity surgery, there is limited, if any, data evaluating MIS in the setting of deformity.

The aim of this study, therefore, was to prospectively compare a matched cohort of patients treated by MIS with standard open posterior surgery for adolescent idiopathic scoliosis (AIS). The primary goal was to compare curve correction between MIS and open posterior techniques used to treat AIS, and secondarily to analyze peri-operative variables between the two groups.

Methods

Between 2009 and 2011, patients enrolled in a multi-center, longitudinal, prospective AIS study were included in the analysis. 16 MIS patients were matched for age, sex, Lenke curve classification, and curve size with 16 conventional open posterior procedures. Pre-operative, peri-operative, and first-erect post-operative data were evaluated. All radiographic data measurements were made by an independent observer. Secondary variables assessed included operative time (minutes), estimated blood loss (cc), and length of hospital stay (days). All cases were also matched to a single surgeon to reduce potential surgeon-induced variability. Institutional Ethics committee approval was received for site participation in the multi-center prospective study and patient informed consent was prospectively in

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place. SPSS V.18 was used for statistical analysis. Although the data was collected in a prospective manner, it was analyzed retrospectively.

MIS surgical technique

Three individual midline skin incisions were planned using fluoroscopy. (Fluoroscopy was limited to pre-operative planning of the incisions). The skin was then undermined laterally to allow for paramedian fascial incisions approximately one fingerbreadth from midline. A blunt muscle sparing approach was used down to the facet joints, which were visualized using hand held retractors. Pedicles were then cannulated using the free hand technique after performing wide facetectomies. Once cannulated, the pedicles remained localized by placement of the guide wires available on the VIPER II system (Depuy, J&J). The facet joints were then meticulously decorticated using a high-speed burr and bone graft was laid down prior to screw placement to help augment fusion. Once the grafting material was laid down (which consisted of freeze-dried allograft bone) the appropriate size pedicle screw was inserted and the guide wire was removed.

Once the screws were placed at all levels an appropriate length rod contoured to the appropriate sagittal profile was introduced. The rod was passed from distal to proximal below the soft tissues and under the skin bridges utilizing the elongated slots designed on the VIPER II cylinders (Depuy, J&J). The cylinders were made collinear prior to placement of the rod allowing for the majority of the deformity correction. The rod was reduced to the pedicle screws using the reduction instruments and secured using set-screws. Further correction was obtained with rod derotation into the appropriate sagittal plane. Prior to placement of the second rod en bloc direct vertebral apical derotation was performed using the VIPER II cylinders. The second convex rod was then under-contoured in the sagittal plane and also placed from distal to proximal. Under-contouring of this rod allowed for further deformity correction in the axial plane. All rods were cobalt chrome and 5.5 millimeters in diameter. The screws were a combination of both polyaxial and uniaxial.

Results

Table 1 summarizes the results. In the MIS group there were 2 males and 14 females, and in the open group the male to female ratio was 1:15. There was a similar distribution of Lenke curve types in both groups. Mean age of the patients in the MIS group was 16.8 years (± 1.2 years) and in the open group was 16.4 years (± 1.2 years). Patients in both groups had near equivalent average body mass index (BMI) and were skeletally mature as determined by their Risser grade.

The pre-op major Cobb angle averaged 56 degrees (± 5 degrees) in the MIS group and was on average 56 degrees (± 8 degrees) as well in the open group. These were corrected to average post-operative major Cobb angles of 20 (± 8 degrees) and 18 degrees (± 4 degrees) (-2.4 - 7.2; 95% CI), respectively giving an average 63% correction (± 13%) in the MIS group and an average 68% correction (± 8%) in the open group, which was not statistically significant (-0.12 - 0.04; 95% CI). The post-operative thoracic kyphosis was on average 21 degrees (± 9 degrees) in the MIS group and 17 degrees (± 5 degrees) in the open group, which was not statistically different (-1.7 - 9.4; 95% CI).

The secondary outcome variables measured operative time (OR), estimated blood loss (EBL), and length of hospital stay (LOS) all of which showed statistically significant differences between the MIS and open groups. In the MIS group, OR time averaged 444 minutes (± 89 minutes) whereas in the open group OR time averaged 350 minutes (± 76 minutes) (34.8 - 154.0; 95%CI). The EBL in the MIS group was on average significantly lower than the open group with 277 ml of average blood loss (± 105 ml) in the MIS group and 388 ml of average blood loss (±158 ml) in the open group (-207.8 - (-14.1); 95% CI). The LOS also showed a statistically significant difference between the two groups with 4.63 days (± 0.96) being the average LOS in the MIS group and 6.19 days (± 1.68) being the average in the open group (-2.6 - (-0.6); 95% CI).

Discussion

This study prospectively compared MIS to open posterior techniques for the treatment of AIS and found no statistically significant difference in curve correction; however EBL and LOS were more favorable in the MIS group at the expense of increased surgical time.

Conventional open spine surgery for deformity is often associated with significant soft tissue disruption, blood loss, prolonged recovery, and post-surgical pain. Standard open posterior approaches have been noted to cause significant soft tissue and muscle morbidity including denervation, ischemia, atrophy, scarring, and decreased extensor strength possibly contributing to increased peri-operative morbidity and long term pain [2,17-28]. MIS has evolved in an effort to decrease the rate of approach-related morbidity associated with conventional open procedures for spinal disorders. Recent advances in MIS technologies have led to the application of MIS in all regions of the spine for decompression, arthrodesis, and instrumentation with widespread use in spinal trauma and degenerative disorders [1,3-5,11,14,16,29]. Several authors have documented decreased blood loss and hospital stay using MIS versus open procedures in these settings [4,5,15,29-32].

	MIS		OPEN			
Demographics						
Gender M:F	2:14		1:15			
Lenke Class (n)	1(8); 2(5); 3(2); 4(1)		1(9); 2(2); 3(3); 4(1); 6(1)			
	Mean	SD	Mean	SD		
Age (yrs)	16.8	1.2	16.4	1.2		
BMI	21	3	22	4		
Risser	4.5	0.5	4.5	0.5		
Pre Op Major Cobb	56	5	56	8		
Primary Outcome	Mean	SD	Mean	SD	95% CI Lower	95% CI Upper
Post-Op Major Cobb	20	8	18	4	-2.4	7.2
Post-Op Thoracic Kyphosis (T5-T12)	21	9	17	5	-1.7	9.4
Percent Curve Correction	63%	13	68%	8	-0.12	0.04
Secondary Variable	Mean	SD	Mean	SD	95% CI Lower	95% CI Upper
OR Time (min)	444	89	350	76	34.8	154.0
EBL (ml)	277	105	388	158	-207.8	-14.1
LOS (days)	4.63	0.96	6.19	1.68	-2.6	-0.6

Table 1: Summary demographics, primary and secondary outcome variables.

In deformity, however, there is limited data focusing on outcomes with MIS techniques. Anand et al. reported their case series of 12 adult patients with degenerative scoliosis who underwent a lateral retroperitoneal approach followed by a posterior percutaneous pedicle screw placement [6]. The average number of segments fused was 3.64. Hsieh et al. presented a descriptive case series of MIS procedures in a heterogeneous group of patients with limited follow-up [13]. Only one patient in their series was treated for deformity. More recently Samdani et al. reported on their experience of MIS in pediatric deformity [33]. Their retrospective review of 15 cases had similar curve correction as noted in our study with an average pre-operative major Cobb angle of 54 degrees and post-operative correction to 18 degrees, giving a 67% correction. The sagittal profile was also reported similar with an average post-operative kyphosis of 26 degrees. The average blood loss was 254cc and OR time was on average 470 minutes.

In this study, although LOS and blood loss were noted to be more favorable in the MIS group, we did find a significantly longer operative time in patients treated with MIS. This may be the effect of a learning curve when applying new techniques but should be emphasized as a potential limitation of MIS in the setting of deformity.

In addition, our study aim was to report on immediate perioperative variables in AIS patients treated with MIS when compared to open techniques. Therefore assessment of fusion rates and/or time to fusion, although important outcome variables, was beyond the scope of this study and longer-term follow-up studies will be critical to assess these principal goals of AIS treatment.

Curve correction, fusion, and rod passage have been raised as theoretical concerns of MIS. The average curve correction of the MIS patients in our study was 63%, which is comparable to the reported literature of 70-80% [34,35]. Fusion may be less of a concern in the pediatric spine as the model for fusion is different than adults. Some authors have reported on unintentional fusion in early onset scoliosis treated with growing rods [36]. In another study, Betz et al. randomized patients to either having no bonegraft (autogenous bone was discarded) or having allograft [37]. They observed one pseudarthrosis in their series, which was in the allograft group.

Limitations of our study include limited follow-up, lack of fusion evaluation and the absence of functional outcomes scores. An accurate, reliable, and reproducible tool for evaluating post-operative pain would also have been useful in the analysis. The study is strengthened, however, by a direct comparison of prospectively collected data on a matched cohort of patients treated by MIS and open techniques.

Conclusions

This is the only reported prospectively matched comparative study of MIS to standard open posterior techniques in the treatment of AIS. We found the early postoperative results of MIS to be similar to open techniques with near equivalent correction of the major Cobb in both groups. Although an increase in the OR time was noted in the MIS group, advantages of MIS over standard open posterior procedures seem to be blood loss, and LOS. Further follow-up will be critical to evaluating the longer-term outcomes of the MIS approach to AIS treatment.

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