Posterior-only surgery with strong halo-femoral traction for the treatment of adolescent idiopathic scoliotic curves more than 100°

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Received: 7 June 2010 / Revised: 25 July 2010 / Accepted: 27 July 2010 / Published online: 12 August 2010
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Abstract The aim of this study was to investigate the feasibility and clinical efficacy of treatment of adolescent idiopathic scoliosis of >100° via posterior-only surgery with strong halo-femoral traction and posterior wide release. From December 2003 to August 2006, 121 patients with adolescent idiopathic scoliosis were treated in our hospital; among them, 29 patients with curves over 100° were included in this study. From December 2003 to June 2005, group A included the first 12 patients who underwent combined anterior release followed by two-week halo-femoral traction and then posterior instrumentation. From July 2005 to August 2006, 17 patients in group B underwent posterior surgery alone with strong halo-femoral traction and posterior wide release. All of the patients were followed-up for a minimum of 31 months (mean, 36 months; range, 31–41 months). There were no severe complications. All of the patients achieved bony fusion without instrumentation breakage or pseudarthrosis. There were no statistically significant differences between the two groups in gender, age, type of adolescent idiopathic scoliosis, preoperative coronal major curve values, major curve flexibility, or final follow-up major curve correction rate. The average operative time, blood loss and hospital stay in group B were less than those in group A. In adolescent idiopathic scoliosis with Cobb >100°, posterior-only surgery with strong halo-femoral traction and posterior wide release can provide comparable curve correction with

shorter operative time, less blood loss and shorter hospital stay when compared to combined anteroposterior surgery.

Introduction

Satisfactory surgical correction in the treatment of severe rigid adolescent idiopathic scoliosis (AIS) achieved by anterior release followed by one- or two-stage posterior fusion has been reported in the literature [1–5]. In recent years, with the application of three-dimensional correction of scoliosis and thoracic pedicle screw technology, a single posterior-only procedure has been used by many authors in the treatment of severe AIS (major curves >90°) with satisfactory results [6–10]. Our study evaluates the feasibility and clinical efficacy of posterior hybrid instrumentation (proximal hooks and distal pedicle screws) with strong traction and posterior wide release in the treatment of AIS with curves of more than 100° and compares this method to the combined anteroposterior approach.

Methods

General materials

From December 2003 to August 2006, 121 patients with AIS were treated at our institution. Twenty-nine patients with major curves more than 100° and Risser's sign 3–5 were included in this study. From December 2003 to June 2005, group A included the first 12 patients who were treated with anterior release and halo-femoral traction in the first stage and posterior spinal fusion and instrumentation two weeks later during a second stage (seven with Texas Scottish Rite

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Hospital, three with China Great wall, two with Cotrell-Dubousset Horizon). This group included three males and nine females with an average age of 15.2 years (range, 14–19 years). From July 2005 to August 2006, 17 patients in group B were treated with strong halo-femoral traction for two weeks and then posterior spinal fusion and instrumentation with posterior wide release and intraoperative halo-femoral traction (ten with Texas Scottish Rite Hospital, four with China Great wall, three with Cotrell-Dubousset Horizon). This group included five males and twelve females with an average age of 15.7 years (range, 13–20 years).

Radiographic data

Group A

The average preoperative coronal Cobb angle of the major curve was 106.3° (range, 102–136°) with an average flexibility of 32% (range, 22–41%). The curve types of these patients were analysed with Lenke classification, and there were two with Lenke 1A+, three with Lenke 1C+, one with Lenke 2AN, one with Lenke 3A+, two with Lenke 3C+, one with Lenke 5CN, and two with Lenke 6C+.

Group B

The average preoperative coronal Cobb angle of the major curve was 107.2° (range, 100–142°) with an average flexibility of 31% (19–44%). The curve types of these patients were analysed with Lenke classification, and there were five with Lenke 1A+, three with Lenke 1C+, two with Lenke 2AN, one with Lenke 3A+, one with Lenke 4C+, three with Lenke 5CN, and two with Lenke 6C+.

Preoperative preparation

Standing long-cassette anteroposterior (AP) and lateral radiographs of the whole spine as well as supine right and left side-bending anteroposterior radiographs of the spine were taken before anterior surgery. Coronal Cobb angles were measured on standing AP film and side bending film. Computed tomography (CT) plain scan and three-dimensional reconstruction of T4–L4 were done. MRI of the spine, including cervical, thoracic, and lumbar segments was performed preoperatively to exclude syringomyelia. Supine preoperative bending radiographs were used to evaluate curve flexibility and Lenke curve classification. Pulmonary function tests and cardiovascular function tests were used to evaluate operation tolerance. In group B, halo-femoral traction, in which the traction weight amounted to 1/4–1/3 of total body weight of the patients, was performed following hospital admission. AP film of the whole spine under traction was made two weeks later. Strategic vertebra

for the placement of pedicle screws or hooks were defined according to the investigations described above.

Surgical procedure

Anterior surgery

Apex and adjacent vertebra of the major curve were exposed from the convex side through a thoracotomy, thoracoabdominal or retroperitoneal approach to release rigid segments. Release segments and asymmetrical segments between bilateral intervertebral spaces were determined by supine convex side-bending postero-anterior radiographs. Anterior longitudinal ligaments, intervertebral disc tissues and endplates were excised. Autologous bone was then placed in the disc space. Closed thoracic drainage tubes were routinely placed. Halo-femoral traction, in which the traction weight amounted to 1/4–1/3 of the total body weight of the patients, was applied at the same stage. Posterior spinal fusion and instrumentation was performed during the second stage two weeks later.

Posterior surgery

The patients were placed in the prone position maintaining halo-femoral traction in which the traction weight amounted to 1/3 of patients' total body weight (in group A, traction was not maintained during the operation). A linear midline skin incision was used. Then posterior elements including lamina, facet joints, transverse processes and costotransverse articulations were exposed. Contracture soft tissues and facet joint capsules on the concave side were released completely. Intertransverse ligaments at the rigid segments were excised. Costotransverse articulation ligaments and costovertebral joint ligaments were also removed. If necessary, parts of the ribs and transverse processes at the apex vertebra were removed. Screws or hooks were installed at the strategic vertebra following satisfactory posterior release. In general, pedicle screws were installed at the levels below T6, and hooks were placed at the levels above T6. Transverse hooks and pedicle hooks formed a claw construction and were used in upper fused segments. Posterior allograft fusion was performed after posterior correction.

Postoperative management

All patients were routinely treated with antibiotics for seven days postoperatively. Dexamethasone of 20 mg/d was administered to patients for five to seven days to reduce allograft bone rejection. The drain was usually removed when the drainage flow was less than 10 ml/24 h. Patients were allowed to ambulate with a brace after remaining supine for 14 days postoperatively. The

braces were continuously used for six to eight months postoperatively.

Statistical analysis

Data are expressed as the mean±standard deviation (SD). Statistical analysis was performed for each dependent variable by comparing the group A versus group B patients by using an independent t-test. A chi-square test was used to analyse differences in gender. All test results with a $p<0.05$ were considered statistically significant.

Results

General materials

There were no statistically significant differences between the two groups with respect to gender or age ($p>0.05$), whereas the average operative time, blood loss and hospital stay in group B were significantly less than those in group A ($p<0.01$) (Table 1).

Radiographic data

In group A, the average preoperative major curve was $106.3\pm 8.5^\circ$ with a flexibility of 0.32 ± 0.05 (Table 2). The average postoperative curve was $50.6\pm 4.2^\circ$ and the final follow-up major curve was $56.8\pm 6.1^\circ$, with an average correction rate of 49.3%. In group B, the average preoperative major curve was $107.6\pm 7.9^\circ$ with a flexibility of 0.31 ± 0.07 . The average postoperative curve was $51.2\pm 5.7^\circ$, and the final follow-up major curve was $58.1\pm 7.3^\circ$, with an average correction rate of 47.7%. There were no statistically significant differences between the two groups with respect to preoperative coronal major curve, the major curve flexibility, or the final-follow-up major curve correction rate ($p>0.05$).

Complications

There were no deaths, spinal cord injuries or vascular injuries among the 29 cases. In three patients, bedsores

were observed that were not severe and were treated with daily dressings. One patient suffered from severe pulmonary function impairment (MMV: 41.5%, FEV1.0: 27.9%, FVC: 46.8%) that deteriorated to even greater severe pulmonary function impairment after anterior release (MMV: 27.2%, FEV1.0: 20.7%, FVC: 40.8%). Pulmonary function recovered after two months of respiratory function exercise. All of the patients achieved bony fusion at the fixation segments without instrumentation breakage or pseudarthrosis. None of the patients presented significant correction loss at the last follow-up (Fig. 1).

Discussion

Combined anteroposterior procedure

Anterior release is classically performed to increase spinal flexibility in severe (larger than 90°) or rigid (larger than 70° on residual side-bending film) scoliosis. A combined anterior and posterior procedure has been considered the classical treatment for treating severe rigid scoliosis [1–5]. Anterior resection of the longitudinal ligaments, intervertebral discs and endplates of rigid segments may significantly improve the compliance of curves and permit a better correction of the deformity with posterior instrumentation. In addition, anterior apical osteotomy may be necessary to achieve adequate curve correction and apical balance in both coronal and sagittal planes [11]. However, both open anterior and endoscopic approaches have a negative impact on pulmonary function compared to a posterior-only approach [12–14], especially in patients with severe pulmonary function impairment. The additional anterior procedure increases surgical trauma, operative time and hospital stay. One patient in group A was admitted with severe pulmonary function impairment. He suffered even greater severe pulmonary function impairment after open anterior release. Therefore, he was unable to tolerate the second stage of surgery. Posterior spinal fusion and instrumentation in second stage was eventually performed after two months of respiratory function exercise.

Table 1 Comparison of general materials and operation situation in the two groups

Group	Gender (male/female)	Age (years)	Hospital days	Blood loss (ml)	Operation time (h)
A	3/9	15.2 ± 1.8	34 ± 5.2	2700 ± 552	8.3 ± 1.7
B	5/12	15.7 ± 1.6	27 ± 3.6	1900 ± 210	5.4 ± 0.6
χ^2/t value	0.0685	0.7873	4.2937	4.7821	5.6655
p value	0.79	0.43	<0.01	<0.01	<0.01

Table 2 Comparison of major curve flexibility and Cobb angle in the two groups

Group	Flexibility (%)	Preoperative Cobb	Immediate postoperative Cobb	Last follow-up Cobb
A	0.32±0.05	106.3°±8.5°	50.6°±4.2°	56.8°±6.1°
B	0.31±0.07	107.6°±7.9°	51.2°±5.7°	58.1°±7.3°
<i>t</i> value	0.4235	0.4231	0.3095	0.9699
<i>p</i> value	0.67	0.78	0.76	0.34

Posterior-only procedure

In recent years, with the application of three-dimensional correction of scoliosis and thoracic pedicle screw technology, one stage posterior-only surgery has been used to treat severe and rigid AIS to avoid the various complications related to the anterior procedure [6, 13].

Dobbs et al. [6] reported that a posterior-only approach using an all-pedicle screw construction had the advantage of providing the same correction as the combined anterior

and posterior spinal fusion in the treatment of severe rigid AIS of curves >90°. They also demonstrated that the anterior release operations had a negative effect on pulmonary function.

Many authors have reported that a posterior all-pedicle screw construction in the treatment of severe and rigid AIS achieved comparable coronal and sagittal correction when compared with the combined anterior and posterior procedure [4]. To our knowledge, few reports have described comparable correction in the treatment of AIS >100° by using

Fig. 1 a,b A 19-year-old girl with idiopathic scoliosis and the Lenke classification was Lenke 4A+. The preoperative major curve was 142° and thoracic kyphosis was 73°. c,d The major curve measured 68° after one stage posterior spinal fusion at 12-month follow-up with a

correction rate of 52%. The thoracic kyphosis measured 41° with a correction rate of kyphosis of 44%. e–h Clinical images at final follow-up show that appearance had improved significantly compared to that observed before treatment

posterior hybrid constructions (proximal hooks and distal pedicle screws) with pre- and intraoperative strong halo-femoral traction and posterior wide release. The mean preoperative Cobb angle of the major curve in the posterior-only procedure group was 107.2° (range, 100–142°). Posterior correction with selective placement of pedicle screws or hooks at strategic vertebra was used. Pedicle screws were installed at levels below T6, and hooks were placed at the levels above T6. Transverse hooks and pedicle hooks, which formed a claw construction, were used in the upper fused segments. After more than two years follow-up in this group, we found that the patients in the posterior-only procedure group presented similar corrective rates and better corrective rates than those previously reported in the literature [1, 6]. This result may reflect the following: (1) the preoperative strong halo-femoral traction for two weeks, which may significantly improve curve flexibility and spinal compliance with intraoperative neuromonitoring, allowed for a better overall correction without the complications that are associated with pure surgical correction of a larger curve, and (2) the posterior wide release at rigid segments may significantly improve the curve compliance of the corrective force. Meanwhile, the instrumental strategy used in our study had several advantages. First, on the premise of guaranteeing satisfactory curve corrective and cosmetic outcome, the instrumentation at the strategic vertebra may reduce the operative cost and permit a greater surface area for interlaminar bone grafting, which is beneficial for long-term fusion compared to the all-pedicle screws at fusion segments. Second, the placement of hooks in the upper thoracic region reduces operative risk and operative time.

Cautions in traction

Because the spinal cord can adapt to slow traction, preoperative gradual increase in weight may improve the tolerance of the spinal cord to correction during operation, and decrease spinal cord injury caused by overcorrection. Halo-femoral traction may increase the time confined to bed which may cause pressure sores and stiffness of the hip and knees. Bedsores that were not severe were observed in three patients, and they were treated with daily dressings. The following points should be noted during traction. First, the traction weight should be increased gradually, to allows the spinal cord to adapt gradually. The traction weight often amounts to 1/4–1/3 of total body weight. Second, intermittent traction is recommended; skin nursing and functional exercise of the hips and knees should be performed regularly. Third, strong halo-femoral traction was applied intraoperatively with intraoperative neuromonitoring to avoid overtraction or overcorrection.

In conclusion, posterior-only surgery with strong halo-femoral traction and posterior wide release can provide correction rates in the treatment of AIS of curves >100° that are comparable to rates obtained using the combined anterior and posterior procedure. The curve flexibility and tolerance of the spinal cord to correction may be improved significantly by intraoperative posterior wide release at fusion segments and perioperative halo-femoral traction. It must be emphasised that although some studies have shown that thoracic pedicle screws offer better correction compared with hook constructions [8, 12, 14], it is prudent to use this technology in view of the dissatisfaction in the accurate placement of upper thoracic pedicle screws [15].

Acknowledgments The study was supported by the Hunan Province Institute of Science and Technology (06SK3015) and the Health Department of Hunan Province of Scientific Researching Fund (B2006040). The authors have no conflicts of interest to declare.

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