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Treatment of fixed thoracolumbar kyphosis in immature achondroplastic patient: posterior column resection combined with segmental pedicle screw fixation and posterolateral fusion

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Abstract A 13-year-old male achondroplastic dwarf with fixed thoracolumbar kyphosis was treated by segmental pedicle screw fixation, posterolateral fusion combined with one stage two level posterior column resection. Preoperative and postoperative kyphosis angles were 97 and 32°, respectively. Combination of segmental pedicle instrumentation with posterior column resection is a treatment option even in immature achondroplastic patients.

Keywords Immature achondroplasia · Kyphosis · Pedicle screw · Posterior column resection

Introduction

Fixed, angular thoracolumbar kyphosis in an immature achondroplastic patient is a difficult spinal deformity to treat, where combined anterior and posterior procedures have been mostly recommended [2, 11, 19, 24].

Segmental pedicle screw fixation has been used safely in several spinal column deformities in pediatric population [1, 4, 14, 20]. It has not been reported in spinal deformities of pediatric achondroplastic patients.

The purpose of this article is to report our 2-year follow-up with an immature achondroplastic patient having fixed thoracolumbar kyphosis where segmental pedicle screw instrumentation was combined with one stage two level posterior column resection.

Case report

A 13-year-old male achondroplastic dwarf was referred to our department after treatment of his hydrocephalus by endoscopic third ventriculostomy. There was a history of progressive thoracolumbar kyphosis since he was 1 year of age. The family history was negative regarding achondroplasia.

Examination at admission revealed the physical findings of achondroplasia. He had an enlarged head, flexion contractures of elbows, and rhizomelic humeri and femurs. His hands and feet were short. He had fixed thoracolumbar kyphosis. On neurological examination he had only mild symptoms such as weakness of the lower limbs on prolonged walking and standing. He had no sphincter disturbance. Babinski sign was negative bilaterally.

On anteroposterior and lateral direct radiographies he had a thoracolumbar kyphosis and upper and lower compensatory hyperlordotic curves. Measurements were done on lateral X-rays for kyphosis and thoracic and lumbar lordotic curves preoperatively

Fig. 1a, b Preoperative anteroposterior and lateral radiographs of the thoracolumbar spine

Fig. 3a, b Postoperative anteroposterior and lateral radiographs. Thoracolumbar kyphosis and compensatory hyperlordotic thoracic and lumbar curves have been corrected

Fig. 2 Preoperative sagittal plane magnetic resonance image shows extensive thoracolumbar kyphosis

and postoperatively (Figs. 1, 3; Table 1). On MRI examination interpedicular distance, pedicle length and height, chord length, pedicle convergence, and sagittal angles were calculated for each level from T1 to L5 (Fig. 2; Table 2) [23, 26]. Interpedicular distance ratio of the L1–L4 vertebra was 1.14, indicating the narrowing of the distance caudally [25].

Surgical technique

The patient was surgically treated for fixed thoracolumbar kyphosis with segmental pedicle screw instrumentation (CD Horizon System, Medtronic Sofamor Danek, Memphis, Tenn.) with one-stage two-level posterior column resection according to the Thomasen technique [21]. The patient lied prone on the operating table. The skin incision was made in the midline from T3 to S1. After exposing the posterior elements of the spinal column, pedicle screws

Table 1 Preoperative, postoperative, and correction values of thoracolumbar kyphosis as well as compensatory thoracic and lumbar hyperlordotic angles

	Pre-operative	Post-operative	Correction
Thoracolumbar kyphosis			
T10–L2	97°	32°	65° (67%)
Thoracic kyphosis			
T4–T11	–40°	–10°	30° (75%)
Lumbar lordosis			
L2–L5	42°	28°	14° (33%)

were inserted between T4 and L4 levels bilaterally. Some 4.5-mm-diameter screws were used between T4 and T10 and 5-mm screws were used at the remaining pedicles sparing T11–L1 segment. The spinous processes and laminae of the T12 and L1 vertebra were removed bilaterally and spinal canal was opened. The articular processes of the same segments and the pedicles removed to the back of the vertebral body by opening the four intervertebral foramina. Through the roots of the pedicles, spongy bone was removed from the interior of both vertebral bodies. The posterior cortex of the body in front of the cord and the back part of sidewalls were cut with a thin osteotome. After engagement of the rods to the screws, the screw heads were not tightened. The operating table was corrected gradually to the flat line while carefully observing the status of the spinal cord during closure of the osteotomy site. A wake-up test was performed in this period and found to be normal. The rods were secured to the screws. Posterolateral fusion was done with autogenous grafts from iliac crest and allogeneous cancellous grafts. There was no intraoperative and postoperative complication. The operation time was 4 h and the estimated blood loss was 2400 ml. He was mobilized with a thoracolumbar orthosis for 9 months. The 2-year follow-up period was uneventful.

Discussion

Fixed angular thoracolumbar kyphosis is estimated to be 10–15% of inappropriately treated achondroplastic popu-

Table 2 Magnetic resonance imaging measurements of the patient. *IPD* interpedicular distance, *PW* pedicle width, *PCA* pedicle convergence angle, *CL* chord length, *PH* pedicle height, *PL* pedicle length, *SA* sagittal angle

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	L1	L2	L3	L4	L5
IPD (mm)	15	15	16	17	19	20	21	18	17	17	16	16	16	16	14	14	17
PW (mm)	5.5	5.5	5.5	6	6	6	6	5.5	7	6	7	7	8	10	10	13	9
PCA (°)	11	12	13	14	15	17	19	16	18	16	20	20	21	22	23	24	25
CL (mm)	21	24	25	28	28	29	30	31	29	33	35	37	36	32	29	29	30
PL (mm)	7.5	7.5	8	8.1	8.3	8.5	8.5	8.5	8.7	9	9	9	9	10	10.5	11	11.5
PH (mm)	5	5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6.3	6.5	6.7	7
SA (°)	35	35	33	31	30	28	27	26	25	25	25	25	25	25	23	24	25

lation. It causes pain, cosmetic deformity, difficulty in sitting and laying flat, and poses risk for neurological deficit [2, 8, 17, 19].

As surgery had been indicated after the development of neurological deficit [5, 10, 17], Hensinger suggested earlier surgical intervention to stabilize the spine and hopefully prevent neurological sequelae [11]. Wide posterior laminectomies, posterior fusion, and anterior decompression with fusion have all been recommended [6, 7, 15, 18]. Winter recommended a combined two-stage approach with anterior disc excision–anterior strut grafting and posterior wide decompression–posterolateral fusion for angular thoracolumbar hyperkyphosis [24]; however, results were uniformly poor in patients with angular kyphosis [2, 6, 24].

To obtain stability after wide laminectomies, hooks and wires were reported to be contraindicated due to diminished size of the spinal canal. That is why posterior stabilization by spinous process wires with Drummond buttresses were used [22]. Lately, pedicle screw fixation has been recommended by Lonstein [15] and Tolo [22].

Recent studies report that pedicle screw fixation achieves higher immediate rigidity [3, 13, 20] and better correction of sagittal plane deformity [4, 9, 16, 20]. Also combining with this, single-stage posterior column resection became more popular in all kinds of spinal deformities with good results [12, 20, 21]; however, long segmental pedicle screw instrumentation has not been reported, to our

knowledge, in immature achondroplastic patients with fixed thoracolumbar kyphosis.

Achondroplastic spine with thickened lamina–inferior facets (namely, posterior bony elements) might have relatively better bony purchase in an immature spine.

Also circular pedicle configuration might be better for bony purchase by a circular screw (Table 2).

Although our patient demonstrated relatively higher degrees of sagittal and horizontal pedicular convergence, pedicle width and height were satisfactory for 4.5-mm screws in thoracic level, whereas 7-mm screws may be used at the lumbar level [22].

As pedicles are short, medial perforation is less likely unless too much convergence is given during screw fixation; however, because there is a relatively small safe zone of 1–2 mm in all levels, due to the increased pressure within the narrow canal, medial penetration may be less forgiving.

The main risk is the extremely short chord length where we used 25-mm screws in all levels.

We think that combined with posterior column resection segmental pedicle instrumentation is optimally matched to the spinal anatomy of even immature achondroplastic spines. We did not consider complementary anterior fusion at this age as there might be a potential for anterior vertebral growth that might further decrease the kyphosis angle.

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