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Technical Report

Posterior curve correction using convex posterior hemi-interbody arthrodesis in skeletally immature patients with scoliosis

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Abstract

BACKGROUND CONTEXT: Deformity progression after posterior fusion in skeletally immature patients with scoliosis has remained a topic of debate. It occurs when the anterior segment of the apical zone continues to grow after successful posterior fusion, resulting in progressive bending and rotation of the vertebral bodies. For this reason, circumferential fusion using a combined anterior-posterior approach has been used to prevent this occurrence.

PURPOSE: The aim of this study was to report instrumented spinal fusion with convex hemi-interbody arthrodesis using a posterior-only approach in Risser stage 0 or 1 scoliosis patients.

STUDY DESIGN: This is a retrospective study.

PATIENT SAMPLE: Three patients presenting scoliosis in Risser stage 0 or 1 were enrolled.

OUTCOME MEASURES: Postoperative correction rate, bone union, and pulmonary function were examined.

METHODS: Premenarchal girls aged 11.3–12.2 years underwent surgical procedure. Follow-up after surgery was on 25, 30, and 36 months. The surgical procedure included soft tissue, costotransverse ligament and facet releases, and Ponte osteotomies. Discectomy followed by intervertebral bone grafting were performed across the periapical zone on the convex side. After placement of segmental pedicle screws, deformity correction was achieved by rod derotation, cantilever reduction, direct vertebral derotation distraction and compression technique.

RESULTS: Preoperative thoracic Cobb angle measured 81° (range 64–107), which improved to 23° at final follow-up, resulting in a 72% correction. Solid posterior bony fusion was achieved in all cases at final follow-up. No case showed deterioration of axial rotation at the apex radiographically. Postoperative pulmonary function showed increases in forced vital capacity (preoperation: 1.86±0.2L; at 2 years: 2.48±0.1L) and forced expiratory volume in 1 second (preoperation: 1.58±0.2L; at 2 years: 2.11±0.1L).

CONCLUSIONS: This posterior-only procedure should be considered a suitable option in skeletally immature scoliosis patients where circumferential fusion is indicated and avoiding an anterior thoracotomy is preferable.

Keywords: Crankshaft phenomenon; CT-based navigation; Hemi-interbody arthrodesis; Posterior approach; Risser stage 0 or 1; Scoliosis

Introduction

In the past several years, excellent posterior fusion in adolescent idiopathic scoliosis has been achieved by a combination of modern strategies [1–4]. Despite achieving successful fusion, there remain concerns about posterior fusion in skeletally immature scoliosis patients because of the risk of postoperative curve progression, including the "crankshaft phenomenon" and "adding on" [5,6]. The crankshaft

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phenomenon after posterior fusion in skeletally immature scoliosis patients has been well documented. It occurs when the anterior segment of the apical zone continues to grow after posterior fusion, causing an increase in bending and rotation of the vertebral bodies. Therefore, several authors have recommended performing a periapical circumferential fusion using a combined anterior-posterior approach to prevent this phenomenon [7–9]. In this technical note, we describe the technique of posteriorly instrumented spinal fusion combined with convex hemi-interbody arthrodesis via a posterior-only approach, and present an illustrative case.

Illustrative case

A 6-year-old girl who presented with early onset scoliosis was followed by an outside hospital for 4 years. During her follow-up, the patient's deformity progressed, and she was referred to our hospital. Her medical history was only remarkable for scoliosis. On physical examination, there were no neurological abnormalities. She had a trunk shift to the right and a rib hump (28°) on forward bending.

Standing X-rays showed a right thoracic scoliosis of 107° with the apex at T10 and 77° of thoracolumbar kyphosis (Fig. 1). On side bending, the thoracic curve decreased to 53°, and the lumbar curve decreased to 27°. Computed tomography (CT) showed no congenital anomalies in the spine and thoracic cage. On magnetic resonance imaging, there were no abnormal findings in the spinal canal. On pulmonary function testing, her preoperative forced vital capacity (FVC) was 1.74L (84.5% of predicted values) and forced expiratory volume in 1 second (FEV1) was 1.61L (92.5% of predicted values). In this case, corrective instrumented fusion and periapical circumferential fusion via a posterior approach was planned.

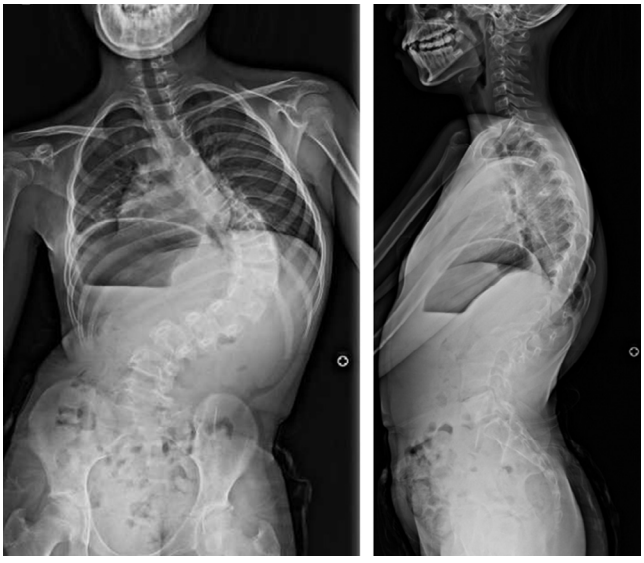

Fig. 1. A girl aged 11 years and 3 months: Preoperative standing X-rays showing 107° of scoliosis with the apex at T10 and 77° of thoracolumbar kyphosis.

Surgical technique: The patient was positioned prone, and the posterior elements from T6 to L3 were exposed through a midline incision. The soft tissue, costotransverse ligament, and facet releases were performed. Segmental pedicle screw insertion was then performed excluding placement of the periapical pedicle screws on the convex side. A CT-based navigation system (Stealth-Station TREON, Medtronic, Sofamor Danek, Memphis, TN) was then brought into the field for visualization of the periapical area and multilevel registration [10] performed (Fig. 2). After Ponte osteotomies in the periapical zone, the facet joints of the convex side were widely removed, avoiding violation of the pilot holes in the pedicles. The lateral border of the dural sac and nerve root was identified before performing the anterior discectomy. During the discectomy, CT-based navigation was used to identify the exact position inside the disc space, avoiding injury to the lung and major vessels (Fig. 3, Left). Local bone grafting was performed at the disc spaces on the convex side. Additional Ponte osteotomies and release of the facet joint at cranio-caudal levels in the apical zone were additionally performed (Fig. 3, Middle). Periapical pedicle screws on the convex side were then placed. Deformity correction was done by placement of a contoured rod on the concave side, followed by cantilever reduction of the thoracic hump with an undercontoured convex rod (Fig. 3, Right). The coronal and sagittal corrections were performed with compression and distraction. Direct segmental vertebral derotation was performed to maximize axial correction.

Postoperatively, there were no complications. At 3 weeks, the thoracic Cobb angle improved to 21° and the thoracolumbar kyphosis decreased from 77° to 36° on standing radiographs. Meanwhile, coronal decompensation to the left was observed. On follow-up examination at 2 years, her coronal decompensation was noted to be balanced, and her rib hump was improved to 8°. There was a mild loss of correction of the thoracic Cobb angle (23°); however, there were no instrument-related problems (Fig. 4, Left). A low-dose reconstruction CT showed a solid fusion of the periapical vertebrae on the convex side (Fig. 4, Right). There was no deterioration of axial rotation in the periapical zone to suggest a crankshaft phenomenon. Her preoperative FVC improved to 2.47L (96.9% of predicted values) and FEV1 to 2.19L (88.7% of predicted values).

Results

We performed this surgical technique in three premenarchal girls who had scoliosis at Risser stage 0 or 1. The upper instrumented vertebra ranged from T2 to T6, and the lower instrumented vertebra ranged from L1 to L3. All patients underwent discectomy and bone grafting of their periapical zones on the convex side. Intra- or postoperatively, massive bleeding more than 1000 mL, neurologic deterioration, surgical site infection, respiratory and instrument-related complications were not observed. The main preoperative Cobb angle measured 81° on average, which improved to 23° at final follow-up,