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Clinical Study

Rod rotation and differential rod contouring followed by direct vertebral rotation for treatment of adolescent idiopathic scoliosis: effect on thoracic and thoracolumbar or lumbar curves assessed with intraoperative computed tomography

Shoji Seki, MD, PhD[a,*], Yoshiharu Kawaguchi, MD, PhD[a], Masato Nakano, MD, PhD[b], Hiroto Makino, MD[a], Hayato Mine, MD[a], Tomoatsu Kimura, MD, PhD[a]

[a]*Department of Orthopaedic Surgery, Faculty of Medicine, University of Toyama, 2630 Sugitani, Toyama 930-0194, Japan*
[b]*Department of Orthopaedic Surgery, Takaoka City Hospital, 4-1 Takaramachi, Takaoka, Toyama, 933-8550, Japan*

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Abstract

BACKGROUND CONTEXT: Although direct vertebral rotation (DVR) is now used worldwide for the surgical treatment of adolescent idiopathic scoliosis (AIS), the benefit of DVR in reducing vertebral body rotation in these patients has not been determined.

PURPOSE: We investigated a possible additive effect of DVR on further reduction of vertebral body rotation in the axial plane following intraoperative rod rotation or differential rod contouring in patients undergoing surgical treatment for AIS.

STUDY DESIGN/SETTING: The study was a prospective computed tomography (CT) image analysis.

PATIENT SAMPLE: We analyzed the results of the two intraoperative procedures in 30 consecutive patients undergoing surgery for AIS (Lenke type I or II: 15; Lenke type V: 15).

OUTCOME MEASURES: The angle of reduction of vertebral body rotation taken by intraoperative CT scan was measured and analyzed. Pre- and postoperative responses to the Scoliosis Research Society 22 Questionnaire (SRS-22) were also analyzed.

METHODS: To analyze the reduction of vertebral body rotation with rod rotation or DVR, intraoperative cone-beam CT scans of the three apical vertebrae of the major curve of the scoliosis (90 vertebrae) were taken pre-rod rotation (baseline), post-rod rotation with differential rod contouring, and post-DVR in all patients. The angle of vertebral body rotation in these apical vertebrae was measured and analyzed for statistical significance. Additionally, differences between thoracic curve scoliosis (Lenke type I or II; 45 vertebrae) and thoracolumbar or lumbar curve scoliosis (Lenke type V; 45 vertebrae) were analyzed. Pre- and postoperative SRS-22 scores were evaluated in all patients.

RESULTS: The mean (90 vertebrae) vertebral body rotation angles at baseline, post-rod rotation or differential rod contouring, and post-rod rotation or differential rod contouring or post-DVR were 17.3°, 11.1°, and 6.9°, respectively. The mean reduction in vertebral body rotation with the rod rotation technique was 6.8° for thoracic curves and 5.7° for thoracolumbar or lumbar curves ($p<.00005$). The mean additional reduction in rotation with the DVR technique was 3.4° for thoracic curves and 4.9° for thoracolumbar or lumbar curves ($p<.00005$). Direct vertebral rotation displayed a slightly but significantly greater additive effect in reducing rotation following initial reduction with rod rotation or differential rod contouring in thoracolumbar or lumbar than in thoracic curves. In the SRS-22 results, postoperative self-image was significantly better than preoperative image in both groups.

FDA device/drug status: Not applicable.

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* Corresponding author. Department of Orthopaedic Surgery, Faculty of Medicine, University of Toyama, 2630 Sugitani, Toyama 930-0194, Japan. Tel.: +81-76-434-7353; fax: +81-76-434-5035.

E-mail address: seki@med.u-toyama.ac.jp (S. Seki)

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CONCLUSIONS: Direct vertebral rotation contributed an additional reduction in vertebral body rotation in thoracic and thoracolumbar or lumbar curves. The DVR technique is likely to be more useful in thoracolumbar or lumbar curve scoliosis than in thoracic curve scoliosis.

Keywords: Adolescent idiopathic scoliosis; Cone-beam computed tomography; Differential rod contouring; Direct vertebral rotation; Rod rotation; Thoracic curve; Thoracolumbar curve

Introduction

The history of surgical treatment for adolescent idiopathic scoliosis (AIS) began with the Harrington rod technique [1], first introduced in 1962. The system uses concave distraction and convex compression to correct scoliosis. Luque's sublaminar wiring technique [2] was introduced in 1982. Although these instruments provided considerable coronal plane correction, these were ineffective in correcting the rotational component. This was addressed in 1988 by the introduction of the Cotrel-Dubousset technique [3], which employs rod rotation.

More recently, Suk et al.'s [4] segmental pedicle screw fixation technique has seen increasing adoption worldwide, and in 2004 Lee et al. [5] reported that direct vertebral rotation (DVR) was effective in correcting vertebral body rotation using segmental pedicle screws. On assessment with postoperative computed tomography (CT) scans, Lee et al. were able to achieve 43% axial plane correction using DVR as compared with only 2.5% without it. Mattila et al. [6] reported that DVR significantly reduced spinal rotation, but had no effect on thoracic rib hump measurements. Whereas DVR is reportedly more effective against apical vertebral rotation than rod rotation alone for Lenke type I or II curves [7], Hwang et al. [8] reported that posterior spinal fusion without DVR using pedicle screws was more effective in correcting lumbar prominence than fusion with DVR in Lenke type V curves. These findings suggest that it is unclear which curve type is best suited to the DVR technique with regard to reducing vertebral body rotation.

Here, we sought to clarify the additive effect of DVR, and to investigate whether one curve type is more amenable to DVR than another.

Materials and methods

Subjects

The study included 30 patients with AIS (28 females, 2 males; mean patient age: 14 years) who underwent rod reduction and differential rod contouring followed by DVR using uniplanar screws at our institution from August 1, 2011 through December 31, 2013. One surgeon (S.S.) performed all the operations. According to the Lenke classification [9] of plain radiographs, 15 patients were type I or II, and 15 were type V. Informed consent to participate in the present study and consent to instrumentation were obtained before surgery. The present study was approved by the ethics committee of the university hospital (IR-90).

Measurement instruments

All subjects were asked to complete the Scoliosis Research Society 22 Questionnaire (SRS-22), a self-administered instrument that contains 22 questions organized into 5 domains covering different aspects of the quality of life: function, pain, self-image, mental health, and satisfaction with treatment. The SRS-22 was evaluated 3 months before and 2 years after surgery in these patients. Questions on satisfaction with treatment in the SRS-22 were evaluated only if the patient had undergone surgery.

Surgical methods

Surgery was performed under general anesthesia in the prone position in all patients. While prone, both buttocks were stabilized with tape to ensure close contact with the operating table, and were tightly secured to prevent slipping. A standard posterior midline incision was made from the cranial end of the pedicle designated for instrumentation to the lamina of the most caudal vertebra designated for instrumentation. The facets included in the fusion and their articular cartilage were removed to promote intraarticular arthrodesis. After performing the Ponte procedure [10] on the apical vertebrae, uniplanar screws (titanium alloy) were inserted into every vertebra by the free hand technique according to the method of Kim et al. [11]. The screw length was chosen to result in 70%–80% penetration into the vertebral body, as seen on a lateral radiograph, to avoid complications of screw overpenetration. Depending on the level of the scoliosis, a concave rod (5.5 mm CoCr) was rotated 90° to transform the scoliosis into a thoracic kyphosis or a lumbar lordosis, and the setscrew of the most caudal screw was tightened to preserve the correction. This was considered the baseline state. Next, a rod was inserted on the convex side and the rib hump was reduced using a differential bending rod, and the setscrew of the lowest screw was tightened to preserve the correction. Last, segmental DVR was performed on each vertebra from the most caudal exposed vertebra to a neutral vertebra cranial to the apical vertebra. Overall balance was checked using plain radiographs. Thoracoplasty was not performed in any patient. Spinal cord monitoring with motor- and somatosensory-evoked potentials was performed during all operations.