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Four-Dimensional Anatomical Spinal Reconstruction in Thoracic Adolescent Idiopathic Scoliosis

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Published outcomes of this procedure can be found at: *Spine (Phila Pa 1976)*. 2018 Oct 1; 43(19):E1135-E1142, *J Orthop Res*. 2018 Dec;36(12):3219-3224, and *Sci Rep*. 2021 Jun 16; 11(1):12622.

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Abstract

Background: Recent surgical techniques involve 3-dimensional (3D) deformity correction of adolescent idiopathic scoliosis (AIS)[1-4]. However, next-generation surgical strategies should ensure that the final corrected spine is not only "non-scoliotic," but has an anatomically correct shape. We developed a 4D anatomical spinal reconstruction technique that involves the use of spatiotemporal deformity prediction to preoperatively calculate the postoperative apex of thoracic kyphosis in order to achieve an anatomically correct spinal curvature[5-7].

Description: During the technique, facetectomies are performed at all levels except the lowest instrumented level in order to avoid pseudarthrosis at that site. Two rods are identically bent according to the desired postoperative anatomical thoracic kyphosis, with the apex often anticipated to be between T6 and T8[5-7]. Two different categories of spinal rod shapes have been created to cover all presenting anatomies. The single-curve rod is utilized when the lowest instrumented vertebra is L1 or above and the thoracolumbar region remains straight. The double-curve rod is utilized when the lowest instrumented vertebra is L2 or L3. With both rod types, the cranial apex is created. There are 11 shapes of pre-bent, notch-free, cobalt-chromium alloy rods available in Japan[7-9]. Once the 2 spinal rods are connected to all polyaxial screw heads, the rods are simultaneously rotated[1,2,5,7].

Alternatives: Typical thoracic AIS exhibits thoracic hypokyphosis. Therefore, correction of the thoracic kyphosis and adjustment of the main thoracic curve are the 2 most important surgical goals for achieving an anatomically correct spine. Furthermore, hypokyphosis of the thoracic spine secondary to pedicle screw instrumentations can be reduced or prevented by utilizing the posterior-approach surgical strategies that we have previously described[1-4].

Rationale: In a healthy human population, the apex of the thoracic kyphosis is normally located at T6 to T8 as viewed on viewing standing sagittal

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radiographs[10]. However, for some patients with AIS, the postoperative apex of the thoracic kyphosis is almost identical to the apex of the preoperative thoracic scoliosis[5], which is not anatomically correct. This insufficient correction is often a result of the spinal rods being bent to match the curvature of the scoliosis[5]. In addition, about 70% of cases of thoracic AIS do not have identical preoperative apices of the main thoracic scoliosis and thoracic kyphosis, and about 33% of cases have the apex of the scoliosis at the lower thoracic spine (i.e., T10 and T11)[5]. Performing sufficient multilevel facetectomies and utilizing the proper spinal rod curvature have been reported to greatly improve postoperative sagittal curve correction[11-13]. This proposed technique could be especially helpful in cases in which the apex of scoliosis is located in the lower thoracic spine, which is often seen in patients with Lenke 1AR scoliosis[14].

Expected Outcomes: When performed with proper shaping of the spinal rods and multilevel facetectomies, the present technique is expected to result in an anatomically correct thoracic spine. The use of this technique has been reported to increase the proportion of patients with a thoracic kyphosis apex at T6 to T8, from 51.3% preoperatively to 87.2% postoperatively[5]. Furthermore, patients who underwent this procedure with notch-free, pre-bent rods had a significantly higher postoperative thoracic kyphosis than patients who underwent the procedure with conventional, manually bent rods[7].

Important Tips:

- Mobilization of the spine by releasing the facet joints is more important than using a rigid implant.
- Two rods are bent identically to the desired postoperative anatomical thoracic kyphosis; the bending is not based on the preoperative scoliosis spinal curvature.
- This technique is applicable for Lenke 1, 1AR, and 2 through 6 curves except for Lenke 5 curves. However, the technique for producing pre-bent rods can also be utilized for Lenke 5 curves because the initial configuration leads to sagittal alignment of the spine.

Acronyms & Abbreviations:

- TL/L = thoracolumbar/lumbar
- UIV = upper instrumented vertebra
- UEV = upper end vertebra
- SD = standard deviation

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