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Technical note

Correction of thoracic adolescent idiopathic scoliosis via a direct convex rod manoeuvre☆

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ABSTRACT

The various techniques available for scoliosis surgery via the posterior approach involve positioning implants on either side of the curve and reducing the deformity by manoeuvres on the concave rod or simultaneously on both rods. Correction solely via a direct convex rod manoeuvre would eliminate the need for implants on the concave side. This technique was used to treat thoracic adolescent idiopathic scoliosis in 23 patients with a mean age of 14 years and 9 months. Low-dose biplanar EOS radiographs were obtained before surgery, on post-operative day 7, and at last follow-up (at least 2 years after surgery) to allow comparisons of Cobb's angle (72°, 33°, and 35°, respectively), thoracic kyphosis (21°, 29°, and 26°), lumbar lordosis (58°, 50°, and 55°), and apical vertebra rotation (– 26°, – 12°, and – 11°). Although scoliosis requires corrections in all three dimensions, this technique seems to produce satisfactory outcomes while obviating the need for implants on the concave side, thereby decreasing the risk of iatrogenic adverse events.

Level of evidence: IV.

1. Introduction

Adolescent idiopathic scoliosis (AIS) usually affects the thoracic spine and is often characterized in the sagittal plane by decreased kyphosis. When performing Cotrel–Dubousset instrumentation, the derotation rod is positioned on the concave side of the curve then rotated to produce sufficient kyphosis [1]. Reports of insufficient vertebral rotation correction with Cotrel–Dubousset instrumentation led to the development of an in situ contouring technique using a pre-contoured concave rod [2]. The correction occurs on the concave side, where implants must therefore be placed. The more recently described technique involving simultaneous translation on two rods combined with derotation on the concave side requires a high density of concave implants or connectors [3]. Another recently reported method uses translation of sublaminar bands and reduction on the concave rod [4,5]. These techniques aim to reduce the coronal deformity and improve kyphosis correction while also derotating the apical vertebra. The same applies to the simultaneous double-rod rotation technique, which also requires implants on the concave side [6].

On the concave side of the curve, the vertebral and pedicular deformities increase the risk of iatrogenic injury due to implants. To decrease this risk, we suggest dispensing with implants on the concave side (at the apical vertebra and at least the two supra- and infra-jacent vertebrae) and evaluating the possibility of deformity correction using only a direct manoeuvre on the convex rod.

2. Technique

Spinal cord monitoring was performed by an electrophysiology physician throughout the procedure. As shown in the video, the operative technique involved arthrectomy of the exposed vertebral levels and instrumentation using mono-axial pedicle screws at the levels nearest the apex of the convexity. On the concave side, the apical vertebra and at least the two supra- and infra-jacent vertebrae were left free of instrumentation. The first rod, made of malleable titanium (U1-R6xxHT, diameter 6) was inserted into the in situ contouring implants on the convex side then locked into the most distal implant. Contouring irons were used to correct the deformity from one level to the next, in the coronal plane then in

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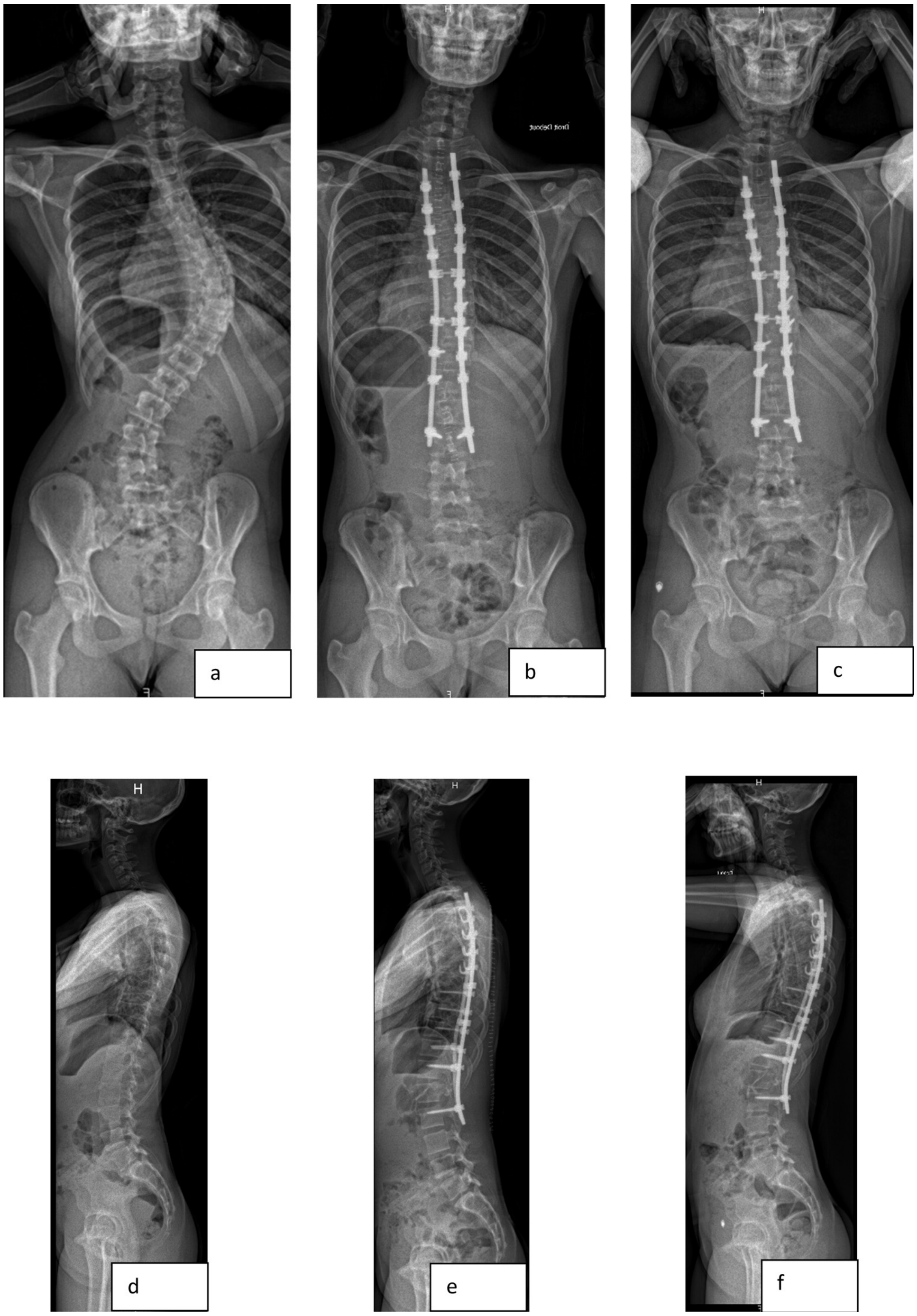

Fig. 1. Female patient aged 14 years at surgery. Antero-posterior radiographs before surgery (a), 7 days after surgery (b), and 26 months after surgery (c). Lateral radiographs before surgery (d), 7 days after surgery (e), and 26 months after surgery (f).

the sagittal plane. The rod was then locked into the most proximal implant. Direct vertebral derotation was applied to the screws at the apex of the convexity, from one level to the next. A second rod, made of rigid titanium (L2-R6xxHT) or cobalt-chrome (U1-R6xxHC) (diameter 6), was inserted on the concave side to stabilise the correction. After bone freshening, transverse connectors were implanted and bone grafting performed using the bone removed during neural arch freshening [7].

3. Results

This technique was used in 23 patients, 19 females and 4 males, between April 2014 and December 2015. Mean age at surgery was 14 years and 9 months (range, 12–18 years) and mean Risser stage was 4. Curve distribution according to Lenke was as follows: 1, $n = 5$; 2, $n = 15$; and 3, $n = 3$. Low-dose biplanar EOS radiographs were obtained before surgery, on post-operative day 7, and at last

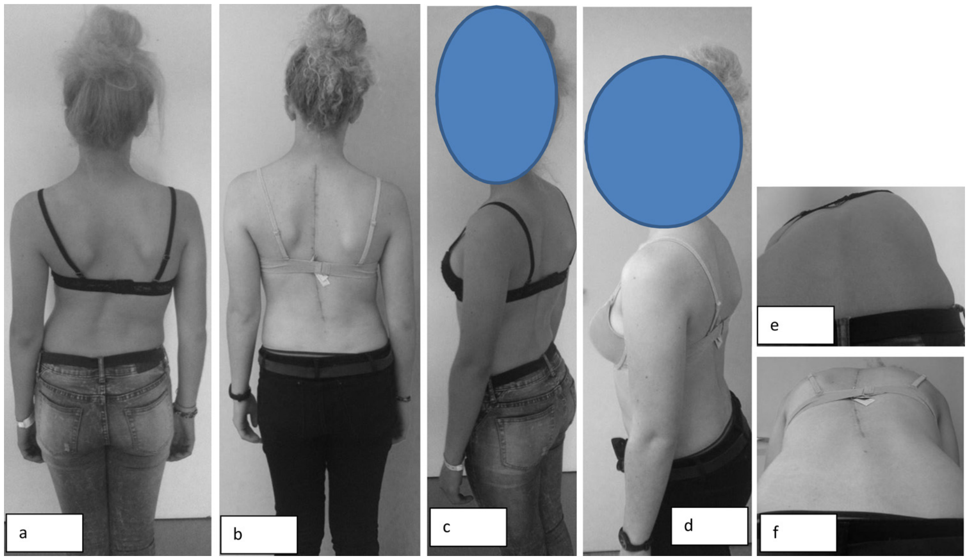

Fig. 2. Photographs of the same patient as in Fig. 1: view from the back before (a) and after (b) surgery; view from the side before (c) and after (d) surgery; view of the gibbus before (e) and after (f) surgery.

Table 1
Angles measured on radiographs before and after surgery.

Mean (range)	Before surgery	Post-operative D7	Last follow-up
Cobb angle	72° (56°;95°)	33° (24°;52°)	35° (24°;52°)
Thoracic kyphosis	21° (– 13°;65°)	29° (– 4°;46°)	26° (– 6°;49°)
Lumbar lordosis	58° (37°;77°)	50° (36°–65°)	55° (40°;68°)
Apical vertebra rotation	– 26° (– 4°;48°)	– 12° (5°;– 28°)	– 11° (– 23°;6°)

follow-up to allow comparisons of Cobb angle, thoracic kyphosis (T4-T12), and lumbar lordosis (L1–L5); in addition, 3D reconstruction using sterEOS software (EOS Imaging, Paris, France) was performed to enable comparisons of apical vertebra rotation (AVR) (Figs. 1 and 2). A follow-up of at least 2 years was required; mean follow-up was 37 months (range, 27–36 months). Table 1 reports the radiographic parameter values at the three time points. Mean instrumentation length was 12 levels. Mean operative time was 230 minutes and mean blood loss was 200 mL. No patient required blood transfusion.

4. Discussion

With this technique, the initial correction from one implant to the next was performed first in the coronal plane then in the sagittal plane in order to create sufficient kyphosis. Then, once the rod was locked at both ends, a direct derotation manoeuvre applied to the screws at the apex from one implant to the next induced no loss of the previously established kyphosis. Compared to other studies in patients with large pre-operative angles (72°), we obtained similar quantitative correction in the coronal plane, as well as in the horizontal plane (from – 21° to – 11° at last follow-up) [8,9]. Despite the improved kyphosis restoration (21° before surgery and 26° at last follow-up), our technique did not allow as much correction in the sagittal plane compared to simultaneous translation on two rods with pre-contouring [10].

Correction techniques involving manoeuvres on the convex side have been described previously but consistently involved instrumentation of the vertebrae at the apex of the concavity [11–13]. Pedicle screw implantation on the convex side is easier and carries less risk of malposition within the vertebral pedicles [14]. Constraints during contouring are less marked, allowing better preservation of the mechanical properties of the rod. Finally, decreasing implant density was recently shown to decrease costs [15].

The main limitations of this study are the retrospective design and small sample size. In the future, follow-up data from the patients will add to the information in this technical note. More specifically, data are needed to determine whether the correction could be significantly improved depending on the evaluation of curve rigidity. Nevertheless, this technique is simple, and during the procedure the surgeon can decide to instrument the concave side if the use of a more conventional method seems desirable.

Disclosure of interest

The authors declare that they have no competing interest.

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Authors' contribution

All authors contributed to the manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.05.007.

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