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ORIGINAL ARTICLE

Vincent Arlet
Dante Marchesi
Patrice Papin
Max Aebi

Decompensation following scoliosis surgery: treatment by decreasing the correction of the main thoracic curve or "letting the spine go"

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V. Arlet (✉)
Montreal Children's Hospital,
Division of Orthopedics,
2300 Tupper Street, Suite C-1112,
Montreal, Quebec, Canada, H3H 1P3
e-mail: arletv@citenet.net,
Tel.: +1-514-9344468,
Fax: +1-514-9344341

V. Arlet · D. Marchesi · P. Papin
M. Aebi
Division of Orthopedic Surgery,
McGill University,
Montreal, Quebec, Canada

Abstract Coronal decompensation following correction of adolescent idiopathic scoliosis (AIS) has been reported to be due to the Cotrel-Dubousset rod derotation maneuver, or to a hypercorrection of the main thoracic curve. The treatment of such decompensation consists classically in observation, bracing, or extension of the instrumentation in the lumbar spine for a King 2 curve, or in the upper thoracic spine for a King 5 curve. As the postoperative decompensation is related to a hypercorrection of the main thoracic curve (relative to the compensatory curve), we hypothesized that if we were to "let the spine go" to some of its initial deformity, the balance of the patient would be improved. The purpose of the study was therefore to report on two cases where a postoperative imbalance following scoliosis surgery was successfully treated by decreasing the correction of the main thoracic curve. Two patients with AIS were found to have significant imbalance after scoliosis surgery. Both patients had been treated for a right thoracic curve (82° and 85° respectively) with an anterior release and posterior instrumentation. The revision surgery consisted for both patients in removing all the hooks between the end vertebrae of the main thoracic curve. This was done before the 3rd postoperative month for both patients. After revision surgery, the balance of both patients improved dramatically within a few weeks. The shoulders became almost level, and the trunk shift improved concomitantly. The Cobb angle increased by 8° and 10°, and the apical vertebra shifted to the right by 15 and 10 mm for the respective patients. These results were stable at 1-year follow-up. In the event of a persisting imbalance, we recommend, in selected cases, letting the spine go by removing all the implants located between the end vertebrae of the main thoracic curve. This adjustment or fine-tuning of the instrumentation should be done before the fusion takes place, and is best achieved with an instrumentation in which the hooks can be easily removed from the rod.

Key words Adolescent scoliosis · Spinal fusion · Postoperative complications

Introduction

Spinal imbalance and decompensation following spinal fusion for adolescent idiopathic scoliosis (AIS) with current instrumentation remains a frequent and unsolved postoperative complication [2, 3, 6, 7, 9, 11, 12, 15, 16, 19]. This complication arose with the use of Cotrel Dubousset instrumentation, and did not seem to occur with the use of the Harrington instrumentation [9], where guidelines for selecting the fusion level have been given by King et al. [4]. The decompensation is mostly encountered in King 2

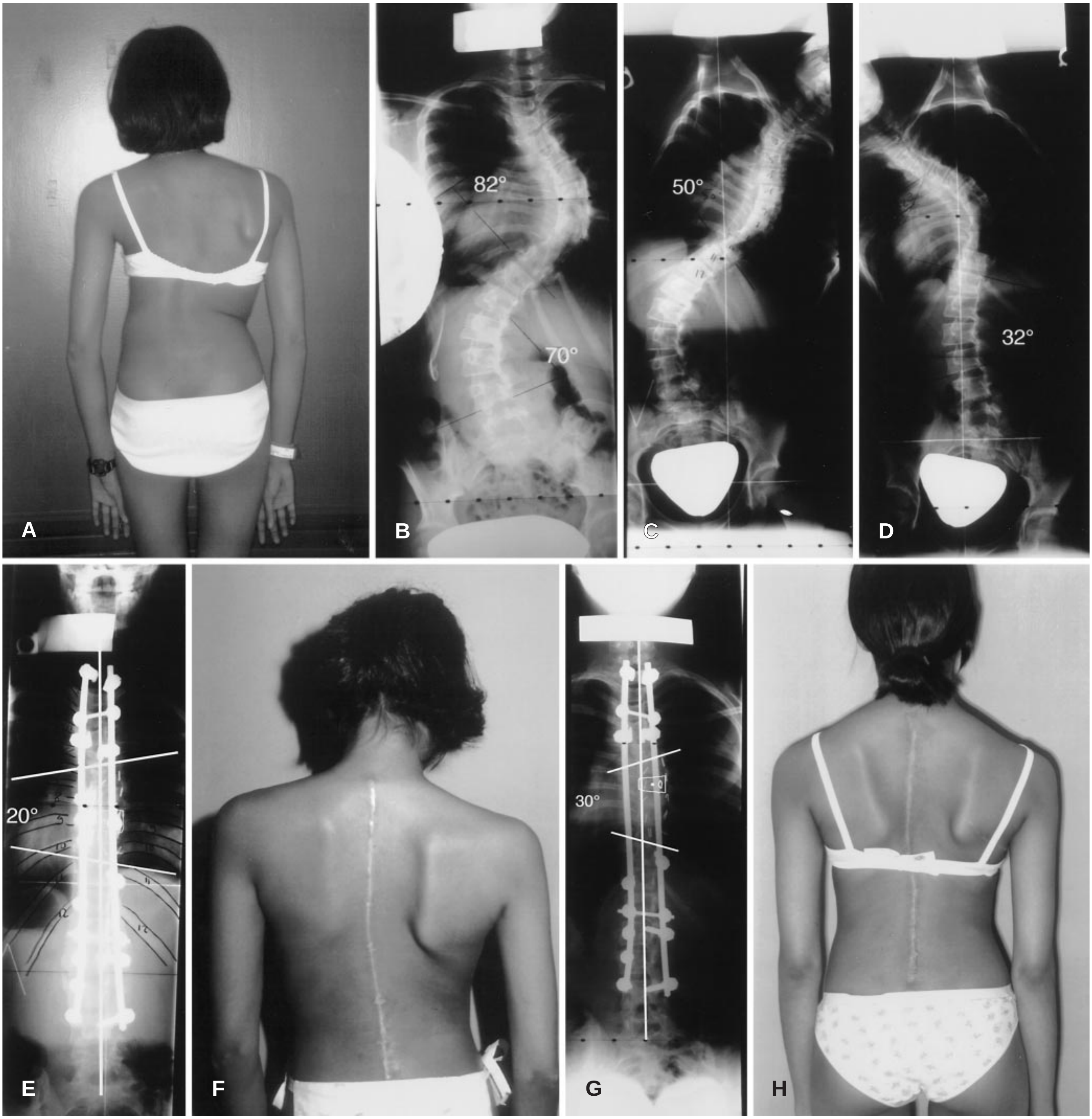

Fig. 1 A–H Patient 1. **A** Preoperative back appearance. **B** The right thoracic curve measured 82°, the left lumbar 70°, the upper left thoracic 34°, the translation of the apical vertebra (T8) from the midsacral line (apical vertebral translation, AVT) measured 75 mm. Risser sign is 0. **C** On convex side bending, the main thoracic curve corrects to 50°. **D** On concave side bending the lumbar curve corrects to 32°, but the upper thoracic shows no flexibility (32°). **E** Two and a half months postoperatively the right thoracic curve measured 20°, the left lumbar 15°, and the AVT only 5 mm. **F** The clinical appearance of the patient is, however, disappointing: the left shoulder is higher than the right by 35 mm, the left scapula is higher, and there is a left trunk shift of 10 mm. **G** Three months after revision and removal of the apical hooks, the Cobb angle now measures 30° and the AVT 20 mm. **H** The left shoulder is now almost at the same level as the right; the scapulae are now at the same level. The trunk shift is fully corrected

curves with a resultant left trunk shift [3, 14], or in King 5 with a left shoulder riding higher after the surgery [5, 7]. In King 2 curves, the treatment of such decompensation varies and can range from simple observation or bracing of the lumbar curve to extension of the fusion down to the lumbar spine in cases of severe decompensation. For King 5 curves, extension of the fusion to the left upper thoracic spine, with appropriate distraction compression, may be necessary to level the shoulders [1, 7]. As the postoperative decompensation is related to a hypercorrection of the main thoracic curve (relative to the compensatory curve), we hypothesized that if we "let the spine go" to some of its initial deformity, the balance of the patient would be improved. The purpose of the study was therefore to report on two cases where a postoperative imbalance following scoliosis surgery was successfully treated by decreasing the correction of the main thoracic curve or letting the spine go.

Materials and methods

Our material consists of two observations.

Patient 1 (Fig. 1)

A 12.5-year-old, premenarchal girl, Risser 0, with adolescent idiopathic scoliosis, was treated via an anterior release from T6 to T11 followed in the same setting by a posterior fusion from T1 to L4 using the AO Universal Spine System (Synthes, Paoli, Pa., USA). A rod derotation maneuver was carried out to achieve correction. Due to the lack of flexibility of the upper thoracic curve (Fig. 1A,D), the intrumentation was extended to T1, in order to maintain the shoulder balance. Distraction of the concavity of the upper thoracic and compression in the convexity was therefore carried out at the time of the index procedure. Postoperative radiographs showed excellent correction of the curves (E). The clinical appearance of the patient was, however, disappointing (F). The revision treatment therefore consisted in removing all the implants between the end vertebrae of the main thoracic curve 10 weeks after the initial procedure (G). As a consequence, the Cobb angle of the main thoracic curve progressed to 30° (10° increase) and the apical vertebral translation (AVT) to 20 mm (15 mm increase) Three months later the patient cosmesis had improved dramatically (H). The result remained stable over 1 year of follow-up.

Patient 2 (Fig. 2)

The second patient was a 15-year-old girl (Fig. 2A) with AIS (85° right thoracic, 50° left lumbar), who had undergone an L4-S1 arthrodesis for a grade 3 spondylolisthesis (Fig. 2B,C). The right thoracic Cobb was at this time 77° and the left lumbar Cobb, 80°. The initial treatment strategy was to reduce the spondylolisthesis and achieve a solid lumbosacral fusion, to which we could later connect the long rod instrumentation for the scoliosis. A domino was therefore left in place at the time of the spondylolisthesis surgery (Fig. 2A). Nine months later, the spondylolisthesis was judged solid (Fig. 2C) and it was decided to proceed with the treatment for the scoliosis. Side bending (Fig. 2D,E) showed a reducibility of 58° for the right thoracic curve and 18° for the left lumbar curve. Therefore, contrary to the initial plan for whole-spine fusion, a treatment plan was chosen aimed at trying to save motion segments in the lumbar spine. The chosen treatment consisted of an anterior release of the thoracic curve from T6 to T11 (because of the rigidity of the curve) and a posterior fusion from T4 down to L1, which was the stable vertebra. The correction was achieved via translation of the spine to a sagittally fixed rod using the AO Universal Spine System. Two months after the operation, the patient was left with a 3.5-cm left trunk shift and a right shoulder elevation of 20 mm, as evidenced on the radiographs and clinically (Fig. 2F,G). Because of persisting imbalance, she was reoperated to remove all the implants between the end vertebrae of the main thoracic curve. Three months later, the balance was much improved, the right thoracic curve measured 44°, the left lumbar 34° (Fig. 2H). The trunk shift was only 15 mm to the left. One can notice a shift to the right in the AVT compared to the radiographs taken before revision. This is best observed if one takes the rods as a landmark. This shift is measured at 10 mm. Her appearance now shows balanced shoulders and a small residual trunk shift of 15 mm (Fig. 2I).

In these two cases, the decision to revise the deformity was done after informed consent to what we would foresee as an improvement of the balance and cosmesis of the patient. The decision was taken after several weeks of observation where no spontaneous improvement had been noticed. The decision was made easier as we use a side-loading, top-tightening instrumentation (AO USS), where the implants can easily be removed from the rod without having to cut the rod to remove them. In both cases, the surgery lasted less than 45 min, with minimal blood loss.

Discussion

Different theories have been proposed to explain spinal decompensation in King 2 curves. The rod derotation maneuver of Cotrel-Dubousset and similar instrumentation was blamed for producing torsional changes in the non-instrumented area that could result in spinal imbalance [3, 12, 19]. Improper selection of the distal fusion level was thought to be the causative factor in a number of cases in which the distal fusion level was not the stable vertebra [19] or when the fusion did not include the lumbar curve, especially in double major curves [2]. Hypercorrection of the main thoracic curve [2] has been blamed for postoperative imbalance, as the non-fused lumbar compensatory curve cannot compensate for the excessive correction of the main thoracic curve. Improper hook strategy and use of distraction forces were also blamed for postoperative imbalance [6, 17]. If the lumbar curve is greater than 45°, especially if associated with a low flexibility index, the chances of spinal decompensation are increased if only a selective thoracic fusion is done, like in King 2 curve [10]. Mason and Carango [9] explain the decompensation by the fact that CD instrumentation and its variants translate the apex of the thoracic curve 1.5 cm further to the left than Harrington rod instrumentation. In a geometric model, Patwardhan et al. [13] have shown that the decompensation was more related to an inadequate relative distance between the thoracic and lumbar apical vertebrae in the postoperative geometry. In other words, too much correction of the apical translation could induce decompensation. Our two illustrated cases, quite different in their presentation and their initial treatment (selective thoracic fusion for patient 2, fusion of both curves for patient 1; derotation of

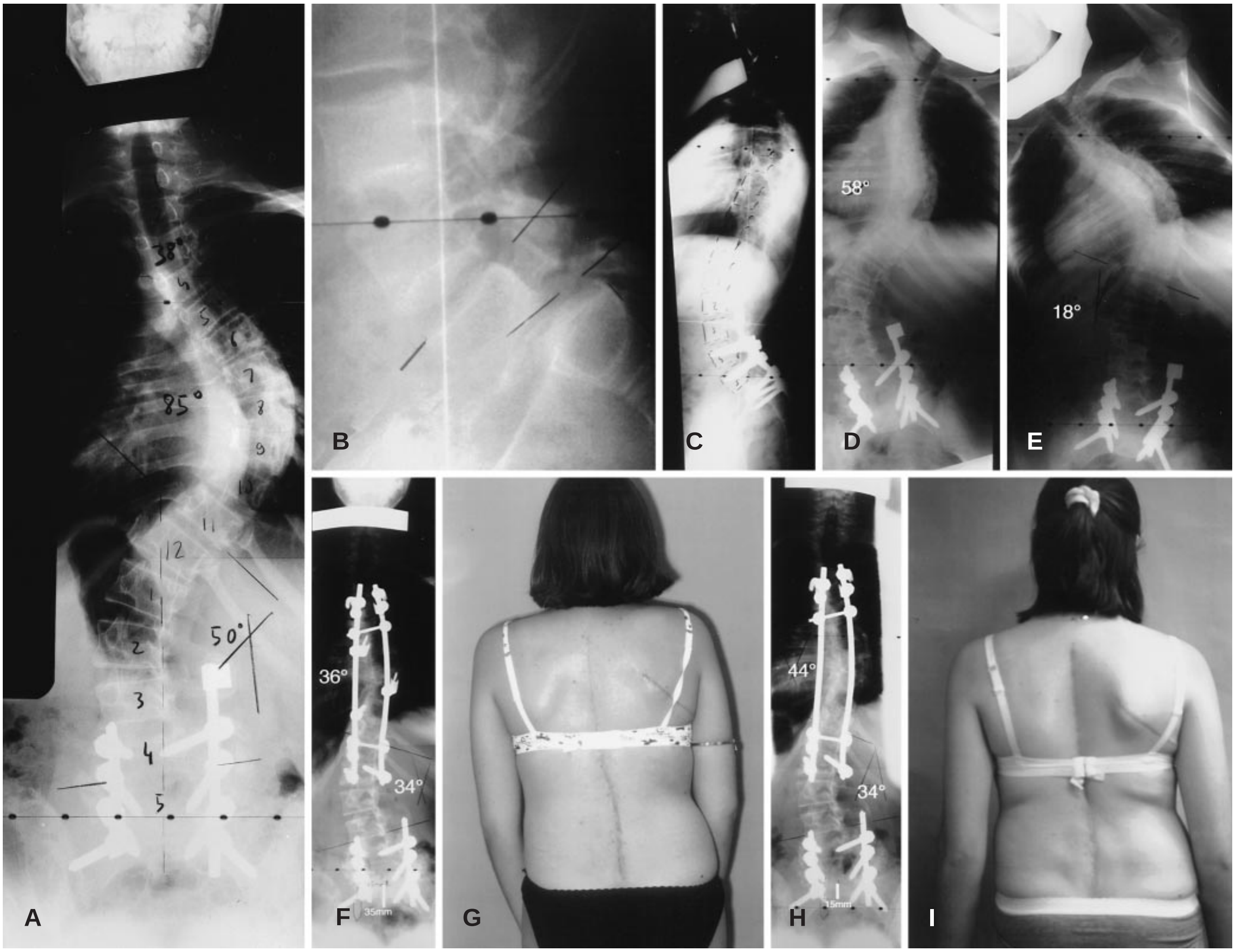

Fig. 2 A–I Patient 2: A15-year-old girl with adolescent idiopathic scoliosis (AIS). The main right thoracic curve is 85°, the left lumbar. 50°. **B, C** Nine months previously, she had undergone an instrumented reduction fusion for a high-grade spondylolisthesis. **D, E** On convex side bending the main thoracic curve corrects to 58°, on concave side bending the lumbar curve corrects to 18°. **F** After anterior release and posterior instrumentation, the main thoracic curve is corrected to 36°, the left lumbar to 34°. The plumb line dropped from the C7 spinous process shows a 35-mm left trunk shift. **G** Clinical appearance of the patient 2 months postoperatively. The shoulder imbalance and the trunk shift are obvious. **H** After revision and removal of the implants from the apex to let the spine go, the Cobb angle has increased and now measures 44°, the trunk shift has improved and is only 15 mm to the left. **I** The appearance of the patient's back has improved, with normalisation of the shoulder imbalance and improvement of the coronal balance

the rod for patient 1, translation of the spine for patient 2), have in fact many points in common. For both patients, it is clear that the decompensation resulted from too large a correction of the main thoracic curve. This can be explained by the anterior release and the excessive posterior correction. A posteriori, in view of these two cases, one may speculate as to whether the anterior release was really indicated. A straightforward posterior instrumentation without anterior release would have resulted in less correction of the main thoracic curve and hopefully no coronal decompensation. With the current modern powerful posterior instrumentation, the indication of anterior release may therefore be restricted to larger and stiffer curves than the ones we treated in the two cases reported here. In these two cases, one can observe, after revision, that the Cobb angle has increased significantly and that there is a shift to the right of the apical vertebrae. These increased values resulted in better equilibrium, as the main thoracic curve balanced the lumbar compensatory curve or the upper left thoracic curve. From these two illustrated cases it is, for us, clear that the rod derotation maneuver does not induce decompensation, as a simple implant removal resolves the imbalance problem. We therefore disagree with previous reports blaming spinal decompensation on this maneuver [3, 6, 19]. Decompensation is the result of a lack of equilibrium between different curves, whether they are instrumented or not. We do, on the other hand, agree with the concept of selective thoracic fusion in King 2 curves as defined by McCance et al. [11], if one chooses the stable vertebra as the distal fusion level and achieves a small correction of the main thoracic curve (provided the lumbar curve remains small). We agree with the hypothesis of Margulies et al. [8], who state that to achieve balance the degree of correction of a curve should be less than, or comparable to the degree of correction attainable at any non-instrumented adjacent curve. This was also supported by Tello [18], who recommended fusing only the thoracic curve when the predicted angular value of the lumbar curve was less than the predicted value of the thoracic curve. Therefore, in King 2 curves one has to choose between the concept of limited thoracic fusion, and therefore limited correction of the main thoracic curve (both in terms of the Cobb angle and translation), or the concept of extending the fusion in the lumbar spine, usually to L3 or L4, to avoid decompensation.

In double thoracic curves, the problem is to achieve a balance of the shoulders. Trying to simplify the problem to whether one should instrument or not the upper thoracic curve (with appropriate distraction compression) has, in our experience, been disappointing. We have found that the more level the shoulders are (or the higher the left shoulder is) preoperatively, the less correction of the main thoracic curve (regarding both the Cobb angle and the apical translation) one should achieve to avoid shoulder imbalance, and the more the main thoracic curve is corrected the more the upper left curve should be corrected. Therefore, in cases of persistent postoperative left shoulder elevation, one should not hesitate to remove the apical implants to let the spine go to help the shoulders rebalance.

When should we consider doing such revision? It is our opinion that one should not wait too long, as spinal fusion will take place and this fine-tuning of the instrumentation may then be useless. On the other hand, one frequently observes some settling of the curves after a while, and shoulder imbalance can improve over time spontaneously. We therefore think that any decision to let the spine go must be taken case by case and according to the surgeon's judgement, and in cases of persisting imbalance. The use of side-opening instrumentation is obviously a plus, as one does not need to remove the rods to adjust the instrumentation, which makes the revision easy and fast.

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