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Is there a need for anterior release for 70–90° thoracic curves in adolescent scoliosis?

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Abstract Large and stiff thoracic scoliotic curves in the adolescent represent a classic indication of anterior release followed by posterior instrumentation. However, third-generation segmental spinal instrumentations have shown increased correction of thoracic curves. Indication for an anterior release may therefore not be required even in large and stiff thoracic curves. The objective of the study was, therefore, to analyze retrospectively the results of third-generation segmental posterior instrumentation in large and stiff thoracic curves and to compare our results with the current literature of anterior release followed by posterior instrumentation. An independent observer, who had not participated in any of the case, reviewed our electronic database of adolescent scoliosis surgery (Scolisoft) with the following query: thoracic curves, Cobb angle between 70° and 90° and posterior surgery only. He was able to identify 19 patients whose thoracic curves were measured between 70° and 90°. Out of these, four had convex-side bending Cobb angle values of less than 45° and were not included in the study, as they were judged too flexible. Fifteen patients (aged 11–18 years, mean 13.6 years) with thoracic scoliosis were left for the study (average Cobb angles 78.5° with a flexibility index of 32.5% (range, 19–42%). The mean follow-up period was 32 months (range 18–64 months). Classic parameters of deformity correction were

analysed. The average operative time was 314 min and the mean total blood loss was 1,875 ml. Average level of instrumented vertebrae was 12 (Range, 10–14). Postoperatively, the thoracic Cobb angle was measured at 34.8° (range, 25–45°), which represents a correction rate of 54% (range, 40.0–67.1%) and remained unchanged at the last follow-up (35°). Patients with thoracic hypokyphosis improved from an average 11° to 18°. There were three complications (one excessive bleeding, one early infection and one late infection). One case showed an add-on phenomenon at the last follow-up. Coronal balance was improved from 1.8 cm (Range 0–4cm) down to 0.75 cm (range 0–2.5 cm). Shoulder balance was improved from 1.3 cm (range 0–4cm) down to 0.75 (0–2.5 cm). All patients reported satisfactory results except the patient with an adding-on phenomena. In the literature, most of the results of anterior thoracoscopic release and posterior surgery give a percentage of Cobb angle correction similar or inferior to our series for an average initial Cobb angle of less magnitude. Therefore, with adequate posterior release, and the use of third-generation segmental instrumentation there is no need for anterior release even for curves in the 70–90° range.

Keywords Adolescent idiopathic scoliosis · Anterior release · Posterior spine fusion

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Introduction

Classically large and stiff thoracic scoliotic curves are an indication for an anterior release, followed by posterior instrumentation. Whether the release is done through thoracoscopy or open surgery remains an area of debate [8]. In a previous meta-analysis of the results of thoracoscopic spine release, we found that most series, including ours, used thoracoscopic anterior release for thoracic curves whose Cobb angle averaged 65° [1]. A more recent publication showed that the average thoracic curve treated with anterior thoracoscopic release had remained at a 65° Cobb angle with an average flexibility index of 34.5% (side bending of 42.7°) [7].

Third-generation segmental spinal instrumentation offers the possibility of instrumenting the most rigid part of the apex with either pedicle screws or a specialized pedicle hook with end-plate screws. With such instrumentation, our clinical impression was that we could correct larger and stiffer curves without the need for an anterior release. Suk had reported that, in curves of less magnitude, a substantial increased correction was obtained with the use of pedicle screws at each level in the thoracic spine [9, 10]. His rate of correction in adolescent idiopathic scoliosis is 70%. Therefore, we thought that, even in stiffer curves, we would have an acceptable correction. The goal of this paper was, therefore, to review our personal experience of posterior-only correction of large and stiff thoracic curves and to compare our results with the available literature of anterior release and posterior instrumentation.

Material and methods

To validate our question as to whether there was a need to perform an anterior release in large and stiff curves, we decided, arbitrarily, to look at curves that were larger and stiffer than the ones reported in our meta-analysis and the recent literature of thoracoscopic anterior release. In these series, the average Cobb angle curve and side bending were respectively 65° and 43° [1, 7, 8]. Only Lenke's recent review article reported a personal series of 21 patients with an average Cobb angle of 82°. We therefore decided to look only at the curves that would measure at least 70° and whose side bending was greater than 45°. In this manner, we would be certain to have a group of thoracic curves that would be, as a whole, larger and stiffer than most of the previously published series reporting on anterior release and posterior correction.

An independent observer who had not participated in any of the cases reviewed our digital electronic database for scoliosis (Scolisoft) and looked at all our surgical cases of thoracic scoliosis operated between January 1995 and January 2002. The Scolisoft database is an electronic registry that includes preoperative, postoperative and last follow-up clinical photographs and X-rays of all our operated scoliosis. Exclusion criteria were patients with less than 18 months of documented follow-up, non-ambulatory patients and patients with conditions such as myelomeningocele, cerebral palsy, or congenital scoliosis.

Thirty three cases of right thoracic curves of more than 70° could be identified. Ten cases measured more than 90° and had all

anterior-release and posterior instrumentation and were therefore excluded. Three cases measured between 75° and 90° and had anterior release and posterior instrumentation and were also excluded. In regard to five other cases with flexible curves that side bent to less than 45°, we decided to exclude them also, as we thought they were too flexible. We were therefore left with 15 patients who underwent surgery for correction of a thoracic curve. The etiology of the deformity was idiopathic for 12 patients. One patient had a cervicothoracic syrinx previously shunted, one patient had a mild form of Charcot-Marie-Tooth disease, and one had Marfan syndrome.

Chart review methods.

Review of the OR reports and hospital and office charts were then carried out. The information reviewed included patient age, gender, menarche, intraoperative parameters (time, blood loss, complications, levels fused), postoperative complications and time in the hospital. The various parameters of spinal deformity assessment, such as trunk shift and shoulder balance, had been prospectively collected in all of our patients. Trunk shift had been measured by the distance of the C7 plumb line to the midsacral line. Shoulder balance had been measured with a spirit level as the difference in height of the two shoulders at the acromioclavicular joint. Review of the digitalized photographs and X-rays for all the patients served to check the validity of the measurement. Precise assessment of the rib hump deformity could unfortunately not be done with enough accuracy, as the use of the scoliometer was unreliable postoperatively in these patients for whom long fusion and stiff spine prevents them from carrying out a proper Adams forward-bending test. Radiographic parameters included coronal and sagittal Cobb measurements. Thoracic kyphosis was measured from T2 to T12 using standard Cobb measurement technique. Each patient had standardized side bending in the supine position, with the arm over the head in a position of maximum inclination to evaluate curve flexibility. Curve flexibility was measured by the Cobb method, measuring the most rigid part of the curve on the side bending independently of the vertebrae chosen for the standing Cobb angle. Likewise, postoperative Cobb measurements were done taking the measurement on the most tilted vertebrae, independently of the vertebral level chosen preoperatively. X-ray measurements were done preoperatively, postoperatively and at the last follow-up.

Surgery methods

Each patient had been operated on with the same segmental instrumentation (AO Universal Spine System Synthes, Paoli, PA, USA) and according to the same principles of correction, without any distraction forces over the main thoracic curves. Surgery was done "à la carte," which means that for each patient the surgery was carried out to achieve the desired goals of deformity correction. These desired goals have remained the following: achieving balance, saving lumbar motion segments, and correcting the cosmetic deformity with special attention to the shoulders and the rib hump. Some cases had convex rib resection or concave rib osteotomies to facilitate correction, reduce the rib hump or create a concave rib hump when the thoracic cage was depressed on the concavity. "A la carte" also means that, in some curves, we did not try to achieve maximum correction of the main thoracic curve in order to maintain balanced shoulders and balanced trunk. This was specifically in the case of King II and King V curves. "A la carte" also means that we had, in a few cases, to perform radical facetectomies (inferior and superior facetectomies) and complete flavotomies to be able to reduce the scoliosis and lordosis. Pedicle screws or specialized pedicle hooks with end-plate screws were inserted in the apex of the curve in all but two patients. Pedicle screws were inserted

after a flavotomy and laminotomy had been done to visualize the medial border of the pedicle for safer screw insertion. A la carte means that we had to use, in the most rigid curves, a combination of spine translation, rod rotation, rod cantilevering, in situ contouring of the rod, or correction of the curve with simultaneous maneuvers of the convex and concave rod to bring the spine across in its final, corrected position.

All our patients had the same fusion techniques. Once the instrumentation had been inserted and correction achieved, numerous corticocancellous strips of bone from the iliac crest or the costectomies were laid on the spine that had been decorticated with a Capner osteotome. No bone substitute was used in any patient of the series.

Results

There were ten girls and five boys. Their average age at operation was 13.7 years (range: 11–18 years). Eight of the girls were pre-menarcheal; two had open triradiate cartilage; six were Risser 0. Curves were classified as King type 2 in four cases, type 3 in four, type 5 in four and double major for three.

The surgery

The average number of fused levels was 12 (range, 10–14). Only four were fused down to L4 and two to L3. The average operative time was 314 min (range, 210–415 min). The mean total blood loss was 1,875 ml (range, 900–3,500 ml). Five patients had costectomies performed at the time of surgery (two concave rib osteotomies, three convex rib osteotomies). The average time in the intensive or intermediate care unit was 1 day (range 0–3 days), and the average time in the hospital before being discharged home was 8.5 days (7–10 days).

Complications

There were three complications. One patient had excessive bleeding of 5,500 cc early in our series. Another patient had a deep wound infection that occurred 6 weeks after surgery and required returning to the operating room for irrigation and debridement in addition to intra-

venous antibiotics. He healed without any sequel. The last patient had a late infection 3 years after his operation, and he required instrumentation removal. His spine fusion was found to be solid.

Clinical and radiographic results

Our results are plotted in Table 1. Our average follow-up period is 32 months (18–64 months). All our patients were well balanced within less than 1 cm of trunk shift at the last follow-up. The shoulders were all balanced within 2.5 cm of discrepancy.

The main thoracic curve was corrected from an initial mean Cobb angle of 78.5° to 34.8° (range 25–45°), which represents a correction rate of 54% (range 40.0–67.1%). This was achieved for a flexibility index (the initial Cobb angle minus the side-bending Cobb angle divided by the initial Cobb angle) of the thoracic curve of 32% (range 19–42%). There was no change between the postoperative Cobb angle and the angle at the last follow-up, except for a patient with adding-on below the instrumented area. The lumbar curve, whether instrumented or not, was corrected from 51° preoperatively down to 21° at the last follow-up.

In the sagittal plane patients with thoracic hypokyphosis ($n=5$), surgery improved their kyphosis to almost normal values. Patients with normal kyphosis retained normal values, and patients with hyperkyphosis were corrected to a normal range of kyphosis (Table 1).

All patients reported satisfactory results following the surgery, except the patient with an adding-on phenomena who happened to have the late infection of this series.

Discussion

The goal of surgery in thoracic scoliosis is definitively not to try to maximize the correction of the Cobb angle. The goals are well-known: to stop the progression of the curve, to correct the curve while achieving balance and a solid fusion, to save levels of fusion and to achieve cosmetic correction.

Table 1 Deformity correction parameters

	Preoperative	Postoperative	Last follow-up
Cobb thoracic	78.5° [70–90°]	34.8° [25–40°]	35.9° [26–45°]
Side bending	53° [47–65°]	--	--
Flexibility index	32% [19–42%]	--	--
Cobb lumbar	51° [30–75°]	21° [14–35°]	20° [15–40°]
Hypokyphotic <20° ($n=5$)	11° [4–15°]	19° [10–28°]	23° [10–30°]
Normokyphotic (20–40°) ($n=5$)	26° [20–35°]	22° [15–26°]	23° [15–30°]
Hyperkyphotic >40° ($n=5$)	52° [43–65°]	26° [18–37°]	30° [23–46°]
Trunk shift	1.8 cm [0–4 cm]	0.75 cm [0–2.5 cm]	0.17 cm [0–1 cm]
Shoulder balance	1.3 cm [0–4 cm]	1.4 cm [0–2.5 cm]	0.75 cm [0–2.5 cm]

Fig. 1 **a** 12-year-old girl, premenarcheal. She presents with significant trunk deformity and marked rib hump; **b** her standing X-rays show an 87° right thoracic curve between T5 and T12, as measured according to the Cobb method. Her sagittal profile is slightly hyperkyphotic; **c** bending films show the curve to be rigid with a limited correction down to 62° ; **d** post-operative and 2-year follow-up scoliosis films. The patient underwent a radical posterior release and posterior instrumentation with convex costectomies. The balance is excellent and the correction has been maintained; **e** more important than the Cobb measurements, the cosmetic appearance is excellent with flattening out of the rib hump, which was treated by costectomies

From our series it appears that we were able to achieve balance and to achieve reasonable correction without the need of an anterior release in any of our cases. We did not observe any loss of correction over time. Loss of correction is classic in series using hooks, but not in series in which pedicle screws had been used [9, 10]. In our series, if we exclude the case in which there was an adding-on, there was no loss of correction in any patient (Fig. 1, Table 1. This can be explained by the use of pedicle screws and specialized pedicle hooks with end-plate screws, which prevented any loss of correction. The crankshaft phenomenon was not observed either, even in the eight patients who were pre-menarcheal at the time of surgery. Although our follow-up is short for this subset of patients (mean, 31 months), we do not think crankshaft is a problem after age 11–12 if one uses segmental posterior instrumentation with screws. This is in keeping with the conclusion of Burton and Asher. They state that scoliotic deformity progression can be prevented in skeletally immature patients with idiopathic scoliosis as young as 10 years of age, by means of stiff segmental posterior instrumentation, without the necessity of concomitant anterior arthrodesis [3]. As to our patient who presented with adding-on, the postoperative result was excellent, but over time his deformity recurred. Crankshaft cannot be the explanation, as the boy was 16 and Risser 3° at the time of surgery. Our explanation is that the fusion was short of the stable vertebra. Revision to remove the instrumentation at the time of the late infection showed the spine fusion to be thick and solid.

Looking at the radiographic parameters, we achieved a correction rate of the main thoracic curve of 54%. This is comparable to most series of thoracoscopic anterior release and posterior fusion, which report a correction rate between 47% and 60% [1, 6, 7, 8] for curves of less magnitude than our series. Recently, Lenke published a report in which thoracoscopic spine release had been done for curves averaging 82°, with a range of 42–125° [5]. Rate of correction in this group was 70%, but Lenke did not specify what kind of posterior instrumentation (hooks or screws) was used for such curves. Likewise, he reports only on angular values and rate of correction but not in terms of postoperative balance and shoulder symmetry. In some cases of major curves where we had done an open anterior release and modern posterior segmental spinal instrumentation, we have observed decompensation of the trunk or shoulders due to hypercorrection of the curve [2]. In our series, in the cases of double thoracic curves we did not aim at maximizing the correction of the main thoracic curve, in fear of inducing a shoulder imbalance, as the upper thoracic curve would be insufficiently corrected. Likewise, we never apply any kind of distraction of the main thoracic curve, as we think it is dangerous neurologically, and it is detrimental for the shoulder and the trunk balance. This means that

our correction rate would have even been much higher if we had tried to achieve maximum Cobb angle correction using distraction of the main thoracic curve at the price of uneven shoulders, trunk decompensation and possible neurologic complication. There is no doubt that adding an anterior release, even done with thoracoscopy, adds in terms of morbidity, surgical time and costs [1, 6, 7, 8]. There is an incidence of 18% of complications with anterior thoracoscopic release [1].

Our posterior surgery time was a little over 5 h, which is far less than the time necessary to perform combined anterior and posterior surgery. Our blood loss was, however, fairly high. If one excludes the patient with 5,500 cc of bleeding, the average blood loss was 1,500 cc. The increased blood loss can be explained by the stiff nature of the curve, the extensive release we have done, including flavotomies and costectomies, and the bone graft harvested from the iliac crest. We still think that we have less bleeding with posterior surgery alone than with a combined front and back surgery, where the anterior bleeding and chest tube drainage adds considerably to the amount of bleeding.

As to the time the patients have spent in the hospital, this is identical to the 9 days average we can find in most series of thoracoscopic release, posterior fusion. The time spent in the ICU or intermediate care is also similar to these series.

When should we consider doing an anterior release? In this series we have managed to correct, perfectly with a very satisfactory result, curves of up to 90° that would side bend to no less than 65°. This is in keeping with Asher's experience. He recently reported his series of large thoracic scoliosis of more than 70° treated with posterior surgery only. We shall quote his results and conclusions: "We interpret our findings as consistent with the viewpoint that adolescent idiopathic scoliotic thoracic curves of about 85° or less Cobb and 35% or more flexibility can be effectively treated with posterior instrumentation and arthrodesis only" [4].

For larger and stiffer curves of more than 90° or that side bend to less than 65°, we have still been doing open anterior release, followed by posterior instrumentation, often after a halo traction period. We do not have the answer for such stiff and large curves. However, new techniques of concave rib osteotomies and radical facetectomies may release the spine enough to do only a posterior fusion even in stiffer curves than the ones we have encountered. Definitively traction films for large and stiff curves may be better than side bending to help us decide the necessity of anterior release [11].

Conclusions

Correction of adolescent idiopathic scoliosis is not a race to achieve the best Cobb angle results, but should aim at

balancing the patient, maintaining balanced shoulders, balanced trunk and an acceptable angular correction. From our series of thoracic curves measuring 70–90°, we have achieved satisfactory correction without any anterior release. There is, therefore, in our opinion no need for

anterior release (whether thoracoscopic or open) for large and thoracic curves that side bend to less than 65°, if one uses a proper combination of radical posterior release, costectomies, and modern, third-generation segmental spinal instrumentation.

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