Does thoracoscopic anterior release of rigid idiopathic scolioses associated with correction by posterior instrumentation result in better long-term frontal and sagittal balance?

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\textbf{KEYWORDS}

Scoliosis;
Thoracoscopy;
Sagittal plane balance;
Spinal deformity

\textbf{Summary}

\textit{Introduction}: The aim of treatment of scolioses is to reduce deformities and restore balance in the spine.

\textit{Hypotheses}: In rigid forms of scoliosis, associating anterior release could provide greater frontal and/or sagittal plane correction and improve balance in the spine.

\textit{Patients and methods}: This study compared correction and long-term balance on two planes between two homogeneous groups of idiopathic rigid scolioses treated with and without thoracoscopic release. The study included rigid scolioses with less than 35% reducibility and a Cobb angle of more than 60°, who all underwent posterior correction using a rod rotation technique. There were 29 patients, 14 who underwent a one-step procedure (group A) and 15 a two-step procedure (group B), with the subgroups of kyphoscolioses and lordoscolioses determined in each group. Frontal balance, Cobb angle, thoracic kyphosis and the Jackson plumbline were measured on pre- and postoperative X-rays and at the final follow-up.

\textit{Results}: The mean long-term final follow-up was 144 months for group A and 54 months for group B. Frontal plane correction was identical in groups A and B. Frontal balance was preserved in all cases at the final follow-up. Sagittal balance was not modified with or without anterior release. The thoracoscopic release step resulted in an additional correction of 15.5° (23%) of thoracic hyperkyphosis in patients with kyphoscoliosis (P=0.003).

\textit{Discussion}: Thoracoscopy did not improve short term results in the Cobb angle or frontal or sagittal balance. Nevertheless, enhanced correction of thoracic hyperkyphosis was obtained with this procedure. In this study, the association of thoracoscopic anterior release with posterior...
Thoracoscopic anterior release of rigid scolioses

Introduction

The treatment of rigid scolioses in adults involves correcting complex three dimensional deformities and restoring balance to the spine. The development of posterior instrumentation in the 1960’s, mainly the Harrington rod technique associated with a brace at first [1], resulted in more effective and permanent correction than traditional non-instrumented fusion. In the 1980’s, as sagittal balance and correction began being taken into account, segmental instrumentation was introduced thanks to the technique by Cotrel and Dubouset [2]. In recent years, other associated concepts have been developed to improve surgical treatment, in particular in situ contouring techniques, rod translation and an increase in the number of fixations with pedicle screws. Associating a step of anterior release to posterior instrumentation and correction in the case of rigid scolioses is an option which should be discussed. The theoretical advantages are increasing short and long-term frontal and sagittal correction, reducing the rate of pseudarthrosis by increasing the surface of fusion and reducing postoperative loss of scoliosis angle correction. However, if anterior release is performed as it is traditionally by thoracotomy or thoracophrenolaparotomy, there is an increased risk of morbidity compared to posterior release and correction alone due to cardiothoracic complications and the duration of surgery. With the development of video-assisted surgery in the 1990’s, certain surgeons began performing thoracoscopic anterior releases with a lower morbidity than that with thoracotomy, associated with posterior instrumentation in rigid scoliosis in adults. The role of anterior release and its indications are a subject of debate [3—7]. Indeed, despite the low morbidity of endoscopic approaches and the popularity of mini-invasive approaches, there is still some debate about the efficacy of two-step correction compared to one-step posterior instrumentation and correction alone, especially on the sagittal plane. Finally, the development of new strategies of instrumentation such as the multiplication of pedicle screw fixations has also made the role of anterior liberation by endoscopy or otherwise, a debatable issue. We performed a long-term retrospective study on correction and balance in the frontal and sagittal plane comparing two homogenous series of idiopathic rigid scolioses with and without thoracoscopic anterior release associated with one-step posterior correction by rod rotation.

Patients and methods

Patients

In this retrospective study, all rigid scolioses included had less than 35% reducibility on traction X-rays and a Cobb angle of more than 60° [8].

Figure 1 Thoracopy: perioperative appearance with trocars in place.

Twenty-nine patients with idiopathic scoliosis were included, 14 underwent surgery by posterior approach alone (group A) from 1986—1996 and 15 were operated in a two-step procedure (group B) from 1996—2001.

A distinction was made in each group between kyphoscolioses (thoracic kyphosis of > 45°) and lordoscolioses (thoracic kyphosis of < 45°).

Epidemiological data are presented in Table 1.

Methods

In group A, the posterior procedure was performed with the patient in the ventral decubitus position, with neurogenic mixed evoked potential (MNEP) monitoring and multisegmental instrumentation (pedicular transverse process claw system, pedicle hooks and pedicle screws). Correction was performed by rod rotation in the concave side of the scoliosis after arthroscopy and lamina debridement. Fusion was performed using cortical bone and biphasic phospho-calcium ceramic mixed with bone marrow. The lowest level of fusion was determined by the reducibility of scoliosis evaluated on traction X-rays.

In the two-step procedure (group B), anterior release was performed the day before posterior correction. Thoracoscopy was performed after selective intubation with the patient in the lateral decubitus position, by an approach on the convex side of the scoliosis. The upper and lower levels of fusion were determined on fluroscopy. Trocars (average of 3) were placed along the mid-axillary line (Fig. 1). After placement of intradiscal electrodes, NMEP monitoring [9] was performed of discectomies that were as complete as possible, then vertebral endplates were debrided by curette. Finally, the debrided disc space was filled with biphasic phospho-calcium ceramic that had been immersed in a bone marrow aspirate obtained by trocar from the homolateral iliac crest. The incision was closed after placement of a thoracic drain in the inferior pleural cavity.
The posterior step was performed with the patient in the ventral decubitus position with MNEP monitoring, multisegmental instrumentation (pedicular transverse process claw system, pedicle hooks and pedicle screws). Correction was performed by rod rotation in the concave side of the scoliosis following arthrectomy and lamina debride-ment. Fusion was performed with cortical bone and filled with biphasic phospho-calcium ceramic mixed with bone marrow.

Retrospective measurements were made of the entire spine on weightbearing AP and profile view X-rays (digitized spine) preoperatively, postoperatively and at the final follow-up. The AP parameters were: frontal plane balance (distance between the vertical line passing through the center of C7 and the middle of the sacral plate) (Fig. 2) and the Cobb angle (Fig. 3). Thoracic kyphosis (Fig. 4) and the Jackson plumbline were measured (vertical line from the center of C7, to the superoposterior angle of the sacral prominence) on the sagittal plane (Fig. 5) [10].

All images were digitized and analyzed with Spine View® software (Surgiview, Paris, France).

The following statistical methods were used: the paired Student t test for paired variables, assuming that variances were not equal, for a retrospective study.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Age (mean)</th>
<th>Standard deviation</th>
<th>Range</th>
<th>Sex</th>
<th>Kyphoscolioses (CT &gt; 45°)</th>
<th>Lordoscolioses (CT &lt; 45°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14</td>
<td>37.05</td>
<td>± 15.7</td>
<td>15.5–57</td>
<td>12 M/2 W</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>24.14</td>
<td>± 9.38</td>
<td>14.7–43</td>
<td>13 M/2 W</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

Group A: posterior correction and instrumentation alone (n = 14); group B: thoracoscopic anterior release then posterior correction and instrumentation (n = 15).
Thoracoscopic operative women difference frontal scolioses, 20.8 in 40.8 postoperative level final 11.2). A significant long-term correction of 15.5° (23%) in thoracic hyperkyphosis ($P=0.003$) (Fig. 6) was obtained in kyphoscolioses alone, although loss of correction between the postoperative and final follow-up was greater in kyphoscolioses in that group (Table 2).

Discussion

The role of anterior thoracoscopic release in adult idiopathic rigid scolioses is controversial. For most authors, the indications for anterior release are a diagnosis of rigid scolioses in adolescents and adults with a Cobb angle of more than 60° and reducibility of less than 35% measured on traction X-rays [8,11]. For certain authors, thoracoscopic release could improve correction compared to posterior instrumented correction alone as well as reduce morbidity compared to thoracotomy [12–14]. Nevertheless, like most techniques, thoracoscopy has a learning curve which affects morbidity [5,15]. For Newton et al. [5], the learning curve based on the duration of excised discs reaches a plateau after 30 cases, which can be considered a large number in the case of rigid scoliosis. Thus, although morbidity is reduced with thoracoscopy [7,16–18] these cases must nevertheless be added to those which may occur by posterior approach and the rate may be higher during the learning period.

Other studies seem to suggest that with the improvements in internal fixation and posterior instrumented techniques, in particular thoracic pedicle screw techniques, anterior release may be unnecessary. In a recent meta-analysis, Arlet et al. [13] concluded that formal criteria showing that thoracoscopic anterior release was more effective than traditional instrumented posterior correction were lacking. In particular, this study showed that comparative studies analysing the degree of angle correction, the quality of disc excision and the quality of the graft were lacking.

In our study, thoracoscopic anterior release did not provide significant long-term improvement in the reduction of the Cobb angle or frontal balance. Moreover, on the sagittal

Figure 6  Comparison of sagittal thoracic Cobb angles and correction between the two groups.

The mean age in group A was 37-year-old (±15.2), with 11 women and three men. The mean age in group B was 24-year-old (±9.4), with 13 women and two men. There was no significant difference between the two groups. The mean follow-up in group A was 197 months (±103) for kyphoscolioses, 91 months (±44) for lordoscolioses, 63 months (±44.3) for kyphoscolioses and 42 months (±26) for lordoscolioses (Table 1).

In the frontal plane

In group A, the mean Cobb angles were: preoperative 80.4° (±14.3), postoperative 43.6° (±15.6) and 46.6° (±14.3) at the final follow-up. In group B, mean Cobb angles were: preoperative 75.5° (±14.7), postoperative 41.3° (±16.7) and 40.8° (±15.9) at the final follow-up.

A mean 4.9 levels were released during the thorascopic anterior procedure. The limits of release were usually level T5/T6 proximally and T11/T12 distally. No significant difference in the reduction of the Cobb angle was found between groups A and B for either kyphoscolioses or lordoscolioses. Frontal plane balance was preserved in the postoperative and final follow-up in both groups. In group A, frontal plane balance was 12.6 mm (±10.1) preoperatively, 20.8 mm (±10.1) postoperatively and 15 mm (±9.8) at the final follow-up. In group B, it was 16.7 mm (±20.1), 20.4 mm (±11.2) and 19.3 mm (±14.2) respectively.

On the sagittal plane

There were six kyphoscolioses and eight lordoscolioses in group A, six kyphoscolioses and nine lordoscolioses in group B. There was no significant long-term difference in the plumbline in either group. In group A, plumbline measurements were as follows: 27.3 mm (±24.7) preoperatively, 32.3 mm (±22.2) postoperatively and 26.6 mm (±20) at the final follow-up. In group B, measurements were 32.4 mm (±20.2), 31.5 mm (±21.9) and 31.5 mm (±16) respectively.

In group B, a significant additional long-term correction of 15.5° (23%) in thoracic hyperkyphosis ($P=0.003$) (Fig. 6) was obtained in kyphoscolioses alone, although loss of correction between the postoperative and final follow-up was greater in kyphoscolioses in that group (Table 2).
Table 2 Comparison of frontal and sagittal parameters with and without thoracoscopic anterior release.

<table>
<thead>
<tr>
<th>Parameter/Group</th>
<th>Preoperative</th>
<th>Immediate postoperative</th>
<th>Final follow-up</th>
<th>Final follow-up</th>
<th>$P$ value at final follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Group B</td>
<td>Group A</td>
<td>Group B</td>
<td></td>
</tr>
<tr>
<td>Cobb ($^\circ$)</td>
<td>43 ± 4</td>
<td>43 ± 4</td>
<td>46 ± 6</td>
<td>46 ± 6</td>
<td>0.9</td>
</tr>
<tr>
<td>Frontal plane balance (mm)</td>
<td>70 ± 14</td>
<td>70 ± 14</td>
<td>73 ± 10</td>
<td>73 ± 10</td>
<td>0.1</td>
</tr>
<tr>
<td>Plumb line (mm)</td>
<td>43 ± 2</td>
<td>43 ± 2</td>
<td>46 ± 3</td>
<td>46 ± 3</td>
<td>0.1</td>
</tr>
<tr>
<td>Thoracic Kyphosis</td>
<td>58 ± 1</td>
<td>58 ± 1</td>
<td>80 ± 0</td>
<td>80 ± 0</td>
<td>0.003</td>
</tr>
</tbody>
</table>

In Table 2, we compare the frontal and sagittal parameters of the thoracic spine between two groups: Group A, which received posterior correction and instrumentation alone ($n=14$); and Group B, which underwent thoracoscopic anterior release followed by posterior correction and instrumentation ($n=15$). The table shows no significant differences in Cobb angles, frontal plane balance, and Plumb line measurements between the two groups at either the immediate postoperative or final follow-up stages. The $P$ values at the final follow-up indicate no significant improvement for Cobb angles or Plumb line measurements, with $P=0.9$ and $P=0.1$, respectively.

Moreover, long-term plumbline measurements were not significantly different with or without anterior release. The only significant improvement was found in the correction of thoracic hyperkyphosis in the subgroup of kyphoscolioses, with an additional significant correction of $15.5^\circ$ (23%) in thoracic hyperkyphosis ($P=0.003$).

The results of the present study are limited because the series only included 29 patients. Nevertheless, this series provides statistically valid results. Moreover, both groups were homogeneous for curve features: rigid idiopathic scolioses included according the criteria described in the literature [8,19].

In relation to possible technical biases, the lack of additional correction by thoracoscopic in our study could be due to an insufficient number of excised intervertebral discs. In a prospective multicenter study of nearly 700 cases (21% of 3311 scolioses reviewed), Guigui et al. [20] reported a mean correction (all techniques combined) of 4.9 levels. Our study was comparable with a mean correction of 4.9 levels. Thus, the distribution of excised discs does not seem to be a technical bias which could explain the lack of benefit. Indeed, the proximal limit was usually T5/T6, which could not be more proximal for technical reasons because the inclination of the discs above T5 made access impossible.

The quality of the discectomy could also be a parameter affecting correction. The surface of excision in the patients in our series was considered to be maximal in a previous CT scan study [21]. Increasing the surface of thoracoscopic resection seemed dangerous considering the CT scan images, because this would have increased the risk of medullar injury (Fig. 7).

We did not perform rib head release which might have improved reducibility, because of the risk of intercostal nerve injury and of increasing the morbidity of the procedure. We used the same rod rotation technique in both groups for posterior correction, which means that the same surgical manoeuvre was used in both groups. Moreover,
instrumentation in the thoracic spine was performed with hooks and the same pedicle transverse process claw system in both groups.

There are now diverse techniques and types of fixation with pedicle systems being more and more frequently used. These developments could potentially influence correction. Asghar et al. [22] reported an additional axial correction of 42% with instrumented correction using pedicle screws compared to hook instrumentation. However, hook instrumentation alone is an older technique which is not representative of recent approaches and the most common techniques combine hooks and pedicle screws.

Luhmann et al. [23] and Se-Ill et al. [24] hypothesized that an anterior step would not be necessary if the posterior procedure included pedicle screw instrumentation. The study by Luhmann et al. showed that if a pedicle screw system was used, anterior release did not improve the Cobb angle or profile in the long-term follow-up. However, they did not differentiate lordoscolioses from kyphoscolioses as in the present study and they did not evaluate the possible affect of anterior release when a hybrid system associating pedicle lumbar screws and thoracic hooks was used.

Se-Ill et al. compared 35 severe idiopathic scolioses treated by posterior instrumentation with pedicle screws alone, with a study by Newton et al. [25] including 112 cases treated by thoracoscopic anterior release associated with a posterior approach. They did not find any difference [24] in frontal plane correction compared to the previous series [25]. However, posterior instrumentation in the Newton study did not include pedicle screws alone. Therefore, the two series were not homogeneous for the two variables that differentiated them: posterior correction and anterior release. Because of this methodological weakness, we felt that that study did not clearly show that anterior release was not effective compared to instrumented posterior correction alone with pedicle screws.

Conclusion

In our study, thoracoscopic anterior release of rigid scolioses associated with posterior correction and fusion by the rod rotation technique did not improve frontal plane or sagittal plane results and only improved correction of thoracic hyperkyphosis in cases of kyphoscolioses. Moreover thoracoscopic has a significant learning curve which increases the morbidity of this two-step approach compared to posterior instrumentation alone. Associating anterior release with posterior instrumented correction in rigid adult scolioses is therefore no longer performed by the authors of this study.

Disclosure of interest

The authors declare that they have no conflict of interest concerning this article.

References