A pedicle subtraction osteotomy as an adjunctive tool in the surgical treatment of a rigid thoracolumbar hyperkyphosis; a preliminary report

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Abstract

BACKGROUND CONTEXT: A pedicle subtraction osteotomy can be considered as part of the surgical treatment of a symptomatic sagittal imbalance. The literature on the use of this technique is limited and thus far not applied to a rigid thoracolumbar hyperkyphosis.

PURPOSE: To evaluate our preliminary results of a pedicle subtraction osteotomy as an adjunctive tool in the surgical treatment of thoracolumbar kyphotic deformities.

STUDY DESIGN/SETTING: Case series

METHODS: Eleven patients with a symptomatic kyphotic deformity were treated with a thoracolumbar pedicle subtraction osteotomy in combination with a multilevel correction. The mean follow-up was 42.8 months (range 26–105). The clinical outcome, radiographic correction, and perioperative complications were analyzed. The results in six more traditional indications (ankylosing spondylitis, kyphoscoliosis, congenital and posttraumatic deformity), were compared with the results in a subgroup of five cases with a rigid thoracolumbar hyperkyphosis.

RESULTS: All patients had a kyphotic thoracolumbar junction. An average of 5.8 levels was involved in the corrective fusion. A pedicle subtraction was always performed between the level Th10 and L2 to correct the sagittal balance. A lordotic correction of 38.8 (range 25–49) degrees was established with this fusion. The osteotomy contributed 66% (26.9 degrees) of the correction, whereas the remaining correction came from multilevel facetectomies. The visual analogue scale for both pain and impairment improved significantly (p < .005) for the entire group. Statistical analysis on the results for both subgroups separately was inappropriate because of the small number of patients available; however, overall both subgroups appeared to do equally well. All patients were very satisfied with the result and would choose surgical treatment again. No major complications were encountered.

CONCLUSIONS: A pedicle subtraction osteotomy is a technically demanding but well tolerated operative procedure for the correction of a kyphotic deformity. This technique can also be considered as an adjunctive tool in the surgical treatment of a rigid thoracolumbar (Scheuermann’s) kyphosis. © 2006 Elsevier Inc. All rights reserved.

Keywords: Thoracolumbar junction; Kyphotic deformity; Pedicle subtraction osteotomy; Case series

Introduction

A symptomatic sagittal imbalance is commonly encountered in patients presenting to spine surgeons [1,2]. A kyphotic deformity can occur after thoracolumbar fractures [3], congenital vertebral anomalies [2,4], and in patients with ankylosing spondylitis [5–9] or idiopathic kyphoscoliosis [10–12]. Patients frequently complain of difficulty in standing erect or low back pain. The lumbar pain is related to fatigue of the spinal extensor muscles and excessive forces on the lumbosacral facet joints. Surgical
treatment frequently is an option in these patients; two methods currently used to correct the sagittal balance are the Smith-Peterson osteotomy and the pedicle subtraction osteotomy [2,4,13]. To achieve lordosis with the Smith-Peterson osteotomy, the posterior column is shortened and the anterior column is lengthened through opening of the disc space. The pedicle subtraction osteotomy has the benefit of obtaining lordosis through both the anterior and posterior column without lengthening the anterior column. This way, there is a good consolidation potential, and stretch on the anterior vessels or the neural structures can be avoided [2,14]. On the other hand the pedicle subtraction osteotomy is technically more demanding because resection of the pedicles in combination with a V-shaped bony wedge from the anterior column has to be performed. Only a few studies are available in the literature on the use of a pedicle subtraction osteotomy. Most of these studies deal with patients with ankylosing spondylitis [6–8], and to our knowledge, there are no data available on the results of a pedicle subtraction osteotomy as part of a primary surgical intervention in patients with a rigid thoracolumbar kyphosis.

In our opinion, it is of key importance to obtain at least a straight, and preferably a lordotic, thoracolumbar junction in these patients. Because we believe that correction of this sagittal alignment it not always possible through the posterior column only, we hypothesized that it may be beneficial to perform a subtraction osteotomy in addition to the more established multilevel Smith-Peterson-like procedure. The purpose of our study was to evaluate the clinical course of our first five patients with this combined approach for a rigid thoracolumbar kyphosis. We decided to evaluate a small number of patients before proceeding on a larger scale. The radiographic and clinical results in these patients were correlated to those obtained in a comparable subgroup of patients with a pedicle subtraction osteotomy for a more traditional indication.

Materials and methods

The radiographs and clinical course of 11 consecutive patients undergoing a pedicle subtraction osteotomy for a kyphotic deformity were studied. All patients were operated on by the same surgeon (PvL). Five men and six women with a mean age of 52.2 years (range 27–77) were operated. The diagnosis was ankylosing spondylitis in three patients, idiopathic scoliosis in one, posttraumatic kyphosis in one, congenital deformity in one, and thoracolumbar kyphosis in five (Table 1). The mean follow-up was 42.8 (26–105) months. Complications were recorded for all patients.

Surgical technique

A pedicle subtraction osteotomy was performed as previously described [4,15]. In summary, the patient was placed prone on a radiolucent table and the thoracolumbar junction was approached posterior. Somatosensory evoked potentials were used along the surgery. All patients had at least a straight, and sometimes a kyphotic, thoracolumbar junction (Th10-L2). The osteotomy was planned at the level where a harmonious lordotic correction of the thoracolumbar junction could best be achieved. In our opinion, this does not necessarily always have to be at the apex of the curve. Multilevel pedicle screws were placed proximal and at least at two levels distal to the osteotomy site. At the adjacent levels, a Ponte type posterior procedure, with extensive interlaminar decompression and total facetectomies, was performed. In this manner, additional lordotic correction through the disc space could be obtained at these adjacent levels.

Subsequently, a laminectomy was performed at the planned osteotomy level. The pedicles were then resected on both sides flush with the vertebral body. Care was taken to preserve the exiting nerve root running along the medial and inferior surfaces of the pedicle. A partial resection of the posterior wall of the vertebral body was performed, followed by a decancellation of a V-shaped wedge of bone. The pedicle subtraction osteotomy was finished by resection of the appropriate amount of bone from the lateral part of the vertebral body bilaterally. The anterior cortex of the vertebral body was preserved to prevent dislocation of the osteotomy during closure of the wedge. The spine was then reconstructed by securing rods to the pedicle screws. Subsequently, the osteotomy was closed by extending the table in combination with compression forces on the adjacent pedicle screws (Fig. 1A, B). In this way, closure of the osteotomy site was achieved with direct bone-on-bone contact.

Postoperatively, all patients had intensive care monitoring at least overnight and intravenous antibiotics for 48 hours. From day 2 patients were mobilized without an orthosis.

Subjective assessment

All patients were administered a subjective questionnaire preoperatively and at the time of the most recent follow-up by an orthopedic resident not involved in the surgery. Both the preoperative and postoperative questionnaires included a visual analogue scale, rated on a scale from 1 to 10, for pain and impairment. In addition, the postoperative questionnaire included items on overall satisfaction and choice for repeated surgery when offered retrospectively.

Radiographic analyses

Long-cassette standing anteroposterior and lateral radiographs were made preoperatively and at regular postoperative follow-up. The preoperative radiographs were analyzed to measure the thoracolumbar kyphosis and the
compensatory lumbar lordosis. Subsequently the levels of fusion and the level of the osteotomy were determined. The radiographs at the last follow-up were used to evaluate the achieved correction of the thoracolumbar kyphosis. The correction at the single-level osteotomy site was also measured and expressed as a percentage of the total correction. In addition, follow-up radiographs were evaluated for potential loss of correction with time, pseudarthrosis, and screw breakage.

Thoracolumbar kyphosis subgroup

In five patients there was a rigid thoracolumbar kyphotic deformity, whereas in the other six patients the hyperkyphosis had a different origin. Both the subjective and the radiographic results in the subgroup of thoracolumbar kyphosis were compared with the results achieved in the more traditional indications. No statistical analysis on the different results in these two groups was performed, owing to the small number of patients in each group. Instead, statistics were calculated on the subjective and radiographic results for the entire group of 11 patients.

Statistical analyses

Preoperative and postoperative variables were analyzed for statistical significance with the Wilcoxon signed-rank test. Results in between groups were compared with the paired t test. Values of $p < 0.05$ were considered significant.

The subgroup of five patients with a structural thoracic hyperkyphosis matched the other six patients for gender, degree of kyphosis, and surgical approach. All osteotomies were performed at the level Th10-L2 (Table 1). Especially in cases of ankylosing spondylitis the osteotomy was done one or two levels more distally. Apart from the ankylosing spondylitis, for the other indications an attempt was made to save as much functional lumbar segments as possible. Also for the thoracic region the fusion was left as short as biomechanically acceptable. This way, in most cases the kyphosis had a different origin. Both the subjective and the radiographic results in the subgroup of thoracolumbar kyphosis were compared with the results achieved in the more traditional indications.

Table 1
Clinical and subjective data on all patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Osteotomy level</th>
<th>Fusion levels</th>
<th>Blood loss (L)</th>
<th>Follow-up (months)</th>
<th>Correction (degrees) Preop</th>
<th>Correction (degrees) Postop</th>
<th>Correction (% Pre Post)</th>
<th>Satisfied</th>
<th>Do again?</th>
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<tr>
<td>1</td>
<td>46</td>
<td>Ankylosing spondylitis</td>
<td>L2</td>
<td>L1-S1</td>
<td>5.5</td>
<td>80</td>
<td>11K</td>
<td>37L</td>
<td>48</td>
<td>100</td>
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<td>L2</td>
<td>L1-L5</td>
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<td>L1-L5</td>
<td>4.5</td>
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<td>T7-L1</td>
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<td>52K</td>
<td>19K</td>
<td>33</td>
<td>16</td>
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</tr>
<tr>
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<td>T10-L1</td>
<td>2.5</td>
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<td>46K</td>
<td>3K</td>
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<td>L2</td>
<td>T12-S1</td>
<td>4.5</td>
<td>26</td>
<td>18L</td>
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<td>T9-L3</td>
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<td>32</td>
<td>35K</td>
<td>9L</td>
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<td>8</td>
<td>73</td>
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<td>T11-L3</td>
<td>3.5</td>
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<td>44K</td>
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<tr>
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<td></td>
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<td>3.8</td>
<td>42.8</td>
<td></td>
<td></td>
<td>38.8</td>
<td>26.9</td>
<td>69</td>
</tr>
</tbody>
</table>

Fusion extended two levels distally from the osteotomy site and two or three levels proximally. Preoperatively for all patients a kyphotic angle was measured at the thoracolumbar junction (Th10-L2), and all but one was corrected into lordosis by surgery (Table 1). In this latter patient, a 42-degree kyphosis from T8 to L3 was corrected, leaving an 8-degree residual kyphosis. For the entire group, an average lordotic correction of 38.8 (range 25–49) degrees of the thoracolumbar kyphosis was achieved (p<.002). This correction was the result of both the single-level osteotomy and the subsequent decompressions at the adjacent levels. The subtraction osteotomy was responsible for 25 (range 12–48) degrees, which accounts for 66% of the entire correction. In all patients, a solid fusion was established and no signs of pseudarthrosis were encountered. In one patient from the thoracolumbar kyphosis subgroup, with an osteotomy at the level Th12 and an instrumentation at the level Th10-L2, a 5-mm pull-out of one of the distal screws occurred at early follow-up. This patient was subsequently treated with a plaster thoraco-lumbo-sacral orthosis for 6 weeks, leading to uneventful fusion with a 5-degree loss of postoperative correction. Eventually, uncomplicated fusion also occurred in this patient.

Subjective assessment

Pain scores (visual analogue scale) improved significantly from 7.9 (SD 2.5) preoperatively to 3.8 (SD 2.8) postoperatively (p=.002) (Fig. 2). From the data obtained, it appeared that traditional indications, especially in the event of ankylosing spondylitis, revealed a more substantial improvement in the pain scores than did patients from the thoracolumbar kyphosis subgroup. Because of the small number of patients, no statistical comparison between the pain scores in these two groups was performed. Also for impairment the scores improved significantly from 7.7 (SD 2.2) to 4.7 (SD 2.2) (p=.003); again no statistical comparison between the two groups was performed. All patients were very satisfied with the result and would choose surgical treatment again.

Fig. 2. Visual Analogue Scale (1–10) for Pain and Impairment for the entire group (n=11) before and after surgical treatment of the kyphotic deformity with a pedicle subtraction osteotomy; both parameters improved significantly (p<.003).
Discussion

The clinical and radiographic results of a pedicle subtraction osteotomy in this small group of patients were good and correspond with the recent literature on this technique [2,4]. Although the number of articles available is limited, the first reports mention a relatively high percentage of serious complications. For this reason, the pedicle subtraction osteotomy has not been a very popular treatment for a long time. However, over the last decade, substantial improvements have been made in the instrumentation techniques available to the spine surgeon. In particular, the introduction of pedicle screws has broadened the spectrum of surgical solutions to spine problems. This improvement likely explains the clearly decreased complication rate of pedicle subtraction osteotomies, as was observed in our patients.

In dealing with the surgical correction of deformities, we tend to focus on a reconstruction of lordosis in the thoracolumbar junction as one of the major goals of our treatment. In sagittal deformities of the spine the thoracolumbar junction is frequently kyphotic, or at least straight, and in our opinion this plays an important role in the development of symptomatic sagittal imbalance. The potential of a Ponte type posterior procedure to restore a lordotic thoracolumbar junction is limited. An additional pedicle subtraction osteotomy can be seen as a powerful tool to achieve lordotic realignment of this area of the spine. We believe that through this additional single-level osteotomy a true shortening of the posterior elements is performed, which leads to a considerable reduction in stresses on the applied pedicle screw fixation. In this manner, the total number of instrumented levels can be minimized. The osteotomy has a good bony healing potential; however, in our opinion at least two levels distally to the osteotomy should be involved in the fusion to avoid biomechanical failure of the construct. Because one patient had some loss of radiographic correction as a result of a minor pull-out of a distal screw, we believe that a two-level instrumentation distally should indeed be considered the absolute minimum. For the thoracic extension of the fusion, there is less reason to minimize the instrumented levels. In the surgical treatment of spine deformities, it is a recognized phenomenon to save as much lumbar levels as possible, whereas for the thoracic region this is less important. In addition, the vast majority of a kyphotic deformity is found to be in the thoracic region, and for this reason we tend to extend the fusion relatively more proximally (Fig. 3). The risk of performing a relatively short fusion also in the thoracic region entails the risk of the development of a junctional kyphosis. Thus, a compromise has to be found in creating a biomechanically stable construct with adequate correction of the deformity, involving as few functional levels as possible.

In our group of 11 patients, a lordotic correction of 38.8 degrees was achieved in the region of the thoracolumbar junction. In all patients a structural hyperkyphosis was encountered, and in our opinion, this amount of correction cannot be achieved with a relatively short fusion through posterior laminectomies alone. Our hypothesis that a single-level osteotomy is a powerful additional tool in achieving a lordotic correction of the thoracolumbar junction was also supported by the fact that a calculated 66% of the entire correction came from this osteotomy.

We did not encounter any major complications or neurological deficits. The procedure was tolerated well,
and uneventful recovery occurred in all patients. On the basis of the pain scores that were assigned at a mean follow-up of more than 3 years, a relief of pain was expressed that was almost four points on a 10-point pain scale. A similar four-point decrease in impairment was experienced.

As more experience was obtained in performing pedicle subtraction osteotomies and only a few complications were encountered, we decided to start performing this procedure on patients with a structural thoracolumbar kyphosis. One of the purposes of the present study was to analyze the preliminary results in our first five patients operated on for this relatively new indication. The data presented indicate that the clinical and radiographic results in these patients seem to correspond with the results in more traditional indications for a pedicle subtraction osteotomy. These are, however, preliminary results in a small group of patients with relatively short follow-up. We are nevertheless encouraged by the results obtained and believe it is acceptable to continue to perform these pedicle subtraction osteotomies in patients with disabling thoracolumbar hyperkyphosis.

References