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Does the preoperative lumbar sagittal profile affect the selection of osteotomy level in pedicle subtraction osteotomy for thoracolumbar kyphosis secondary to ankylosing spondylitis?☆

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ABSTRACT

Objective: To investigate the different preoperative lumbar sagittal profiles of ankylosing spondylitis (AS) patients and the selection of osteotomy level for one-level pedicle subtraction osteotomy (PSO) for the correction of thoracolumbar kyphosis.

Patients and methods: Seventy-one consecutive AS patients with an average age of 35.3 years and a mean follow-up time of 35.9 months who underwent one-level PSO for thoracolumbar kyphosis were divided into 2 groups based on their preoperative lumbar sagittal profiles as follows: group A, lordotic lumbar sagittal profiles; and group B, kyphotic lumbar sagittal profiles. The following radiological parameters were measured and compared: chin-brow vertical angle (CBVA), global kyphosis (GK), thoracic kyphosis (TK), lumbar lordosis (LL), sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT) and sacral slope (SS). Clinical evaluation included Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS). Perioperative and mid-term complications were reviewed.

Results: There were 28 patients in group A and 43 in group B. The preoperative LL was −21.0° in group A and 2.3° in group B ($P < 0.05$). The preoperative SVA was 122.5 mm in group A and 184.3 mm in group B ($P < 0.05$). All the patients in group A (100%) underwent PSO at L1/L2, while 90% of group B patients underwent PSO at L2/L3, with no significant difference of postoperative GK, LL and SVA between the 2 groups ($P > 0.05$). No obvious loss of correction was observed in either group at the final follow-up. The correction of LL and SVA showed a strong but not statistically significant increasing trend as the PSO level descended from L1 to L3 ($P > 0.05$). The postoperative ODI was significantly lower in patients underwent PSO at L1 or L2 ($P < 0.05$).

Conclusions: Patients in group B had significantly worse preoperative sagittal alignments compared to group A. The distribution of osteotomy levels varied between the 2 groups due to the different lumbar profiles; however, satisfactory correction was achieved in both groups. The preoperative lumbar profiles need to be considered in selecting the optimal osteotomy level. Patients with kyphotic lumbar profiles are suitable candidates for PSO at L2/L3, while L1/L2 PSO is appropriate for patients with lordotic lumbar profiles.

1. Introduction

Ankylosing spondylitis (AS) is a chronic rheumatic inflammatory disease affecting the axial skeleton and causing ossification of ligaments and discs [1–3]. In the later stages of this disease, progressive ossification can induce rigid thoracolumbar kyphosis, preventing the patient from looking straight ahead [4,5].

For severe thoracolumbar kyphosis induced by AS, spinal osteotomy is needed to reconstruct the sagittal alignment and to restore the patient's capacity to see the horizon [6–8]. More recently, pedicle subtraction osteotomy (PSO) has been proven to be an effective procedure to correct AS-related thoracolumbar kyphosis [9,10]. In the surgical decision-making of single-level PSO, selection of the optimal osteotomy level, which remains debatable, is a key factor contributing to correction results. Two options have been well-documented: osteotomy at the lower lumbar vertebra, and osteotomy at the apical vertebra. A previous study reported that osteotomy should be performed at lower lumbar vertebra to achieve greater correction of the

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SVA and good restoration of global sagittal alignment [11]. Recently, Chen et al. pointed out that osteotomy should be done at the apical vertebra, because a favorable contour can be achieved by attacking directly on the angular pathology [12]. Another study assessing the clinical results of AS-related thoracolumbar kyphosis corrected by PSO deemed that osteotomy over lower level can achieve better sagittal alignment due to the long lever arm [13].

Although surgeon and institution experiences of PSO have been well-discussed in literature, to date, there have been no firm conclusions of the optimal osteotomy level in single-level PSO. The selection of the osteotomy level in practice varied by surgeon preference and in different cases. Based on our observation, surgical decision making of the osteotomy level largely depends on the preoperative lumbar sagittal profile. Given the inconsistent and sometimes conflict conclusions in the literature, a deep understanding of different patterns of lumbar sagittal profiles in AS patients is needed. Thus, the current study seeks to find out a classification of lumbar sagittal profiles in AS patients, focusing on the selection of the optimal osteotomy level in single-level PSO.

2. Patients and methods

2.1. Subjects

A retrospective review of 105 consecutive AS patients with thoracolumbar kyphosis who underwent PSO from May 2006 to April 2015 at our institution was performed. The diagnosis of AS was based on the Modified New York Criteria [14]. The inclusion criteria were the following: (1) AS patients who underwent one-level lumbar PSO for thoracolumbar kyphosis; and (2) a follow-up of at least 2 years. Patients with pseudarthrosis, previous spinal surgery and pathological fractures were excluded. Finally, a group of 71 AS patients met the inclusion criteria (63 men/8 women, with an average age of 35.3 years and a mean follow-up of 35.9 months). The lumbar sagittal profile was categorized as lordosis (group A) if all of the centroids of the lumbar vertebrae distal to the apex were anterior to a reference line connecting the midpoint of the inferior endplate of the apex and L5 (Fig. 1a), while the kyphotic group (group B) was defined as having at least one centroid posterior to the reference line (Fig. 1b) [15]. For further analysis, all 71 of the patients were divided into 3 subgroups: group L1 (osteotomy at L1), group L2 (osteotomy at L2) and group L3 (osteotomy at L3).

2.2. Radiological evaluation

The following sagittal spinal parameters were measured on standing lateral radiographs: (1) chin-brow vertical angle (CBVA) [16], calculated as the angle between the chin-brow line and vertical line; (2) global kyphosis (GK) [17], measured as the angle formed by the lines parallel to the superior/inferior endplates of the maximally tilted upper/lower end vertebrae; (3) thoracic kyphosis (TK) [18], determined by the angle between the T5 superior endplate and the T12 inferior endplate; (4) lumbar lordosis (LL) [19], determined by the angle between the T12 inferior endplate and the S1 superior endplate (negative value: lordosis; positive value: kyphosis); (5) sagittal vertical axis (SVA) [20], the shortest horizontal distance between the sacrum posterior-superior edge and the plumb line from C7; (6) pelvic incidence (PI) [21], defined as the angle between the line vertical to the superior margin of S1 and the line connecting the sacral plate midpoint with the hip joint axis; (7) pelvic tilt (PT) [22], measured as the angle between the line connecting the sacral plate midpoint to the hip joint axis and the vertical line; and (8) sacral slope (SS) [23], measured as the angle between the sacral plate and the horizontal line.

2.3. Clinical evaluation

Clinical data including age, gender, Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) of lumbosacral pain and hardware failure at the final follow-up were reviewed.

2.4. Statistical analysis

All of the calculations were performed using SPSS statistical software, version 14.0 (SPSS 14.0, Chicago, IL, USA). The paired-samples *t*-test was used to compare preoperative and postoperative data and the results at the final follow-up. The independent samples *t*-test was applied to determine the differences in radiological outcomes between the two groups and among the three subgroups. $P < 0.05$ was considered statistically significant.

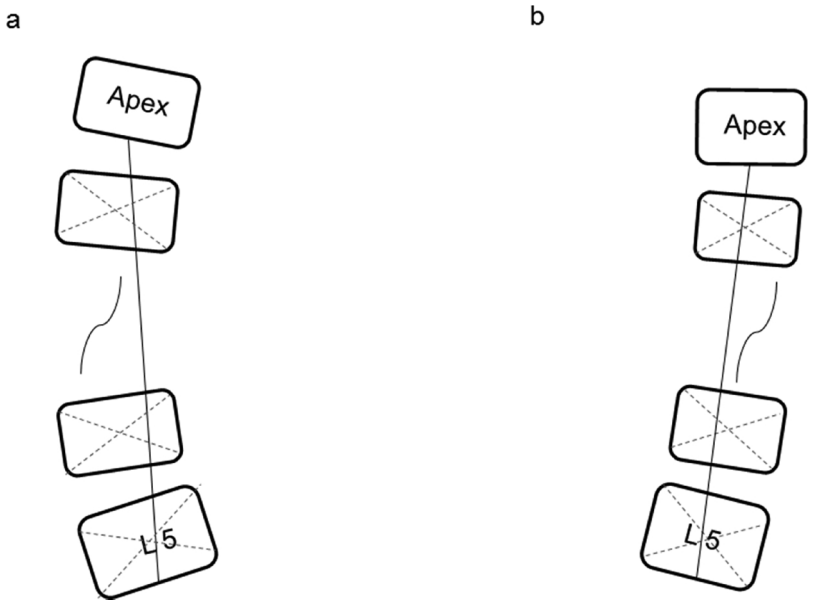

Fig. 1. Illustration of lordotic (**a**) and kyphotic (**b**) lumbar sagittal profiles. A reference line is defined by connecting the midpoint of the inferior endplates of the apex and L5.

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