ORIGINAL ARTICLE

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Results of closing wedge osteotomy in the treatment of sagittal imbalance due to ankylosing spondylitis

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Objective: Ankylosing spondylitis is a systemic disease which affects the axial skeleton and may cause rigid spinal deformities in advanced cases. Clinical and radiological results of patients with ankylosing spondylitis who underwent pedicle subtraction osteotomy (PSO) were evaluated.

Methods: Twelve (3 female, 9 male) patients who were treated for rigid spinal deformities due to ankylosing spondylitis were evaluated. All patients were treated with the same surgical technique, which included PSO and pedicle screw-rod combination. For radiological results, thoracic kyphosis, lumbar lordosis, pelvic parameters (pelvic incidence, sacral inclination, pelvic tilt), and the distance between the central sagittal line (CSVL) and the sacrum were measured from pre- and postoperative radiograms. For functional results, SF-36 and Oswestry Disability Index (ODI) were used.

Results: Mean age of the patients was 39.8±8.4 years, and mean follow-up was 85.6±39.1 months. Mean angle of lordosis was improved from 6.6°±13.7° preoperatively to 43.8°±8.4° postoperatively ($p<0.0001$). Mean CSVL was improved from 19.7±9.7 cm preoperatively to 7.45±3.8 cm postoperatively ($p=0.0005$). Mean local angular change around the osteotomy site was 30.2°±6.2°. The pelvic parameters were not significantly changed after the surgeries. Mean ODI, SF-36 mental, and SF-36 physical scores were 30.16±9.7, 41.2±9.9 and 35.3±7.1, respectively.

Conclusion: In patients with rigid sagittal spinal deformities due to ankylosing spondylitis, lumbar lordosis and sagittal balance can be obtained using PSO.

Keywords: Ankylosing spondylitis; closing wedge osteotomy; lumbar osteotomy; pedicle subtraction osteotomy.

Level of Evidence: Level IV, Case series.

Ankylosing spondylitis (AS) is a seronegative chronic inflammatory disease which usually affects the axial skeleton. Its incidence is 0.5–14 per 100 000 people and prevalence is between 1% to 1.4%.[1] The disease is seen more commonly in males than females and usually appears in the third decade of life.[2,3] At the advanced stages of the disease, calcification of the ligaments results in rigid sagittal plane deformities of the spine.[3,4] The major complaints of patients are restrictions on movements of the body, deformities, pain, and abnormal position of the head due to sagittal imbalance, which leads to vision problems.[4,5]

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Sagittal plane deformities in patients usually occur in the thoracolumbar region as kyphosis; approximately 30% of patients present with this complaint.[4] Anterior colon lengthening or posterior colon shortening are recommended to correct rigid sagittal plane deformities of patients with AS, and osteotomies are described for this reason.[4,6–10] Because anterior colon lengthening of the spine creates high risk for the neurovascular structures, posterior colon shortening osteotomies are recommended.[11–13] Smith Peterson osteotomy and pedicle subtraction osteotomy (PSO) are two of the posterior colon shortening osteotomies. PSO is shown to be more effective than Smith Peterson osteotomy in the correction of sagittal plane deformities of patients with AS.[14,15]

The aim of this retrospective study was to present radiological and functional results of PSO in patients with severe sagittal spinal deformities due to AS.

Patients and methods

Twelve patients diagnosed with AS were operated between 1998 and 2011 using PSO for the correction of sagittal plane deformities of the vertebral colon and were evaluated retrospectively. In order to determine the latest clinical and radiological findings, all patients were called and invited to the hospital within the 6 months prior to performing this study.

All patients were operated using the posterior approach (Figure 1). After paraspinal muscles were elevated subperiosteally and retracted, pedicle screws were inserted under fluoroscopy control to at least 2 vertebrae above and below the osteotomy level using transpedicular technique. At the planned osteotomy level, after posterior structures of the vertebral colon were removed using a rounger and wide laminectomy was performed via high-speed burr and Kerrison rounger, the neighboring nerve roots were retracted and preserved. Following temporary rod fixation, anterior colon osteotomy stage of the surgery was started (Figure 2). A wedge-shaped osteotomy was performed through the pedicles and body of the vertebrae, with careful retraction of the nerve roots. Two 6.5-mm titanium rods were placed to the screws, and the osteotomy site was closed by compression of the screw-rod constructs.

Antibiotic prophylaxis (cefazolin sodium 70 mg/kg/day) was applied to all patients for the first 48 hours postsurgery. Only mechanical prophylaxis for deep venous thrombosis was performed using anti-embolism stocks and early controlled ambulation.

Radiographic evaluations were made on the anteroposterior and lateral scanograms. Thoracic, lumbar, and sagittal parameters were measured using the Cobb method. Angle of kyphosis was measured between the upper end plate of the T4 vertebrae and lower end plate of the T12 vertebrae; angle of lumbar lordosis was measured between the upper end plates of the L1 and S1 vertebrae. Pelvic parameters were evaluated using measurements of pelvic incidence, pelvic tilt, sacral slope, central sacral line (CSVL), and angle of T1 spinopelvic inclination on the preoperative, early postoperative, and control radiographs.[16] All radiographic measurements were made by the same spine surgeon using Surgimap software (DePuy Synthes, New York, NY, USA).

Fig. 1. Preparation of the patient in the prone position for the osteotomy. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

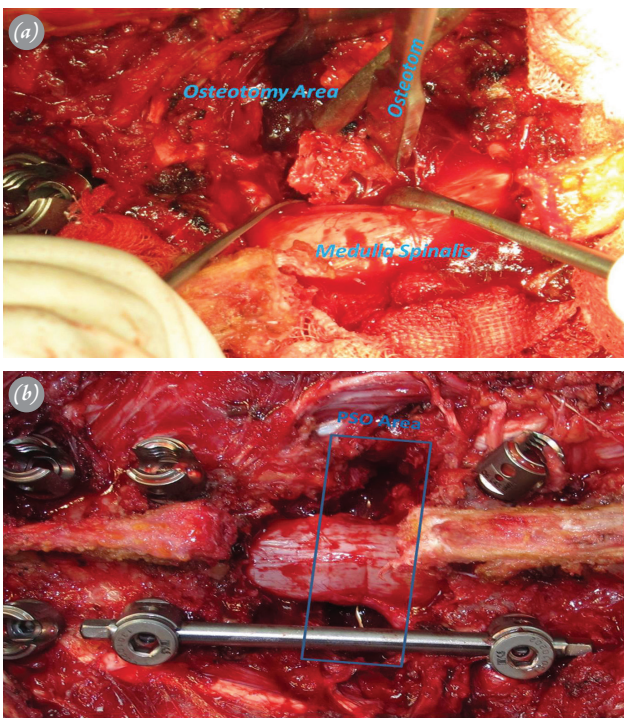

Fig. 2. **(a)** Anterior corpus osteotomy after insertion of the pedicle screws and transient rod fixation. **(b)** The figure shows appearance of the medulla spinalis and the posterior structures of the spine. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

For the evaluation of patient satisfaction, patients completed the SF-36 short form health survey and Oswestry Disability Index (ODI).

Statistical investigations were performed using SPSS software (version 20.0, SPSS Inc., Chicago, IL, USA). Paired t-test and analysis of variance were used for parametric data, and Fisher's exact test was used for nonparametric data. A p value <0.05 was accepted as statistically significant.

Results

Mean age of the patients (3 women, 9 men) was 39.8±8.4 years. Mean follow-up was 85.6±39.1 months (Table 1). PSO levels were L1 in 3 patients, L2 in 3 patients, L3 in 4 patients, and L4 in 3 patients; 1 patient underwent 2 levels of osteotomy (Figure 3).

In radiographic evaluations of pelvic parameters, changes in values of mean preoperative and postoperative sacral slope (-1.4±18.6 vs 0.3±24.5), pelvic incidence (48.6±10.9 vs 50.3±14.2), pelvic tilt (50±19.4 vs 49.6±0.3), and T1 spinopelvic inclination (6.3±12.7 vs -1.2±5.4) were not statistically significant (Table 2).

Mean angle of lumbar lordosis improved from 6.6°±13.7° preoperatively to 43.8°±8.4° postoperatively (p<0.0001). Mean amount of CSVL decreased from 19.7±9.7 cm preoperatively to 7.45±3.8 cm postoperatively (p=0.0005). Mean angular correction of the osteotomy site was 30.2°±6.2°, while correction of the lumbar lordosis was 36.6°±10.6° (Table 2). Although the difference between the 2 values was not statistically significant (p=0.08), the correlation was significant (p=0.045).

In clinical evaluations, preoperative mean ODI, SF-36 mental health component, and SF-36 physical component scores were 79±4.1, 29.3±3.9, and 23.4±2.3, respectively. At final follow-up, mean ODI, SF-36 mental health component, and SF-36 physical component scores increased to 30.16±9.7, 41.2±9.9, and 35.3±7.1, respectively. The difference between preoperative and postoperative ODI (p=0.001), SF-36 mental health component (p=0.013), and SF-36 physical component (p=0.001) scores were statistically significant.

Table 1. Demographics of patients' preoperative and postoperative functional results.

Parameters	Mean±SD	Range
Age (years)	39.8±8.4	25–52
Gender	3 female, 9 male	
Follow-up (month)	85.6±39.1	16–146
Short form 36 physical functioning preop	23.4±2.3	20–26
Short form 36 mental preoperative	29.3±3.9	23–34
Oswestry Disability Index preoperative	79±4.1	68–84
Short form 36 physical functioning postoperative	35.3±7.1	33–60
Short form 36 mental postoperative	41.2±9.9	26–44
Oswestry Disability Index postoperative	30.16±9.7	8–48

SD: Standard deviation.

Table 2. The parameters measured on the preoperative and postoperative standard radiographs.

Parameters	Preoperative	Postoperative	p
	Mean±SD	Mean±SD	
Sacral slope (°)	-1.4±18.6	0.3±24.5	0.84
Pelvic incidence (°)	48.6±10.9	50.3±14.2	0.75
Pelvic tilt (°)	50±19.4	49.6±30.3	0.96
Lordosis (L5–S1) (°)	6.6±13.7	43.8±8.4	<0.0001
Angular change in lordosis (°)	–	36.6±10.6	0.08*
Angle of osteotomy (°)	–	30.2±6.2	0.045**
Kyphosis (T4–T12)	53.7±23.8	54.3±8.4	0.94
Central sacral line (cm)	19.7±12.7	-1.2±5.4	0.11
T1 spinopelvic inclination (°)	6.3±12.7	-1.2±5.4	0.11

SD: Standard deviation. Results of the *statistical analysis and **correlation tests between the angles of change in lordosis and the osteotomy.

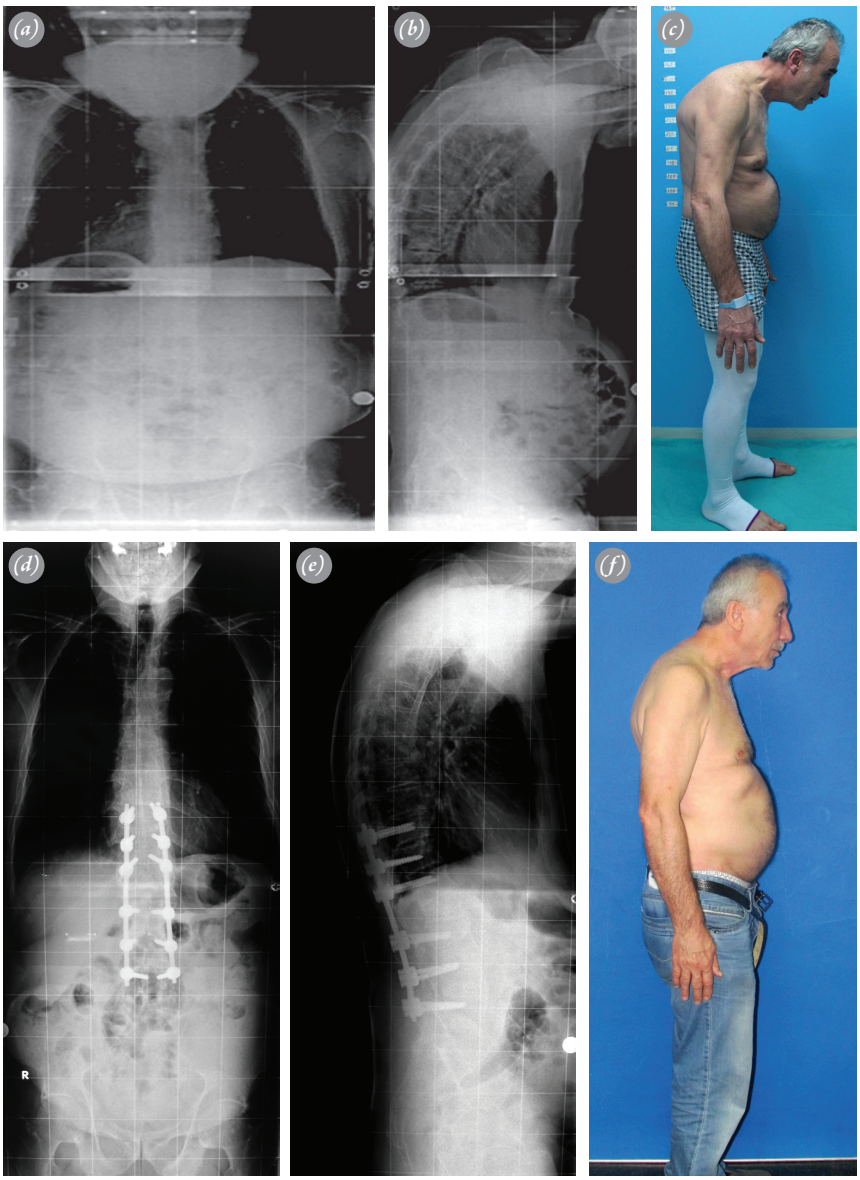

Fig. 3. A 52-year-old male patient with the diagnosis of ankylosing spondylitis was treated with L1 PSO and instrumentation between the levels of T11 and L5. Preoperative anteroposterior **(a)** and lateral **(b)** orthoroentgenograms and posture of the patient **(c)**. Anteroposterior **(d)** and lateral **(e)** orthoroentgenograms and posture of the patient remained corrected at final follow-up **(f)**. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

There was only 1 complication of junctional kyphosis at the distal level, which occurred in a patient due to insufficient distal instrumentation level; this was treated surgically by lengthening the instrumentation level distally.

Discussion

Corrective osteotomies of the spinal deformities due to ankylosing spondylitis are usually required in order to improve vision, decrease pain, and correct imbalanced posture.[14,17–19] Correction of rigid sagittal plane deformities can be achieved by osteotomies. In the literature, in addition to open or closed wedge osteotomies of the spine, multiple lumbar wedge osteotomies are described.[4,6–10]

Successful radiological results were reported in the literature comparing open and closed wedge osteotomies.[14,20] As a complication of open wedge osteotomies, injuries of the anterior vascular structures due to lengthening of the anterior colon have been reported.[21] In the literature, mortality of closed wedge osteoto-

mies was reported as 1.3%, while it was 5.8% for open wedge osteotomies.[10] Because the rate of complications in closed wedge osteotomies is lower and radiological results are the same as open wedge osteotomies, it is the more-preferred technique in AS.[14,15,22] However, in a review comparing open and closed wedge osteotomies by Ravinsky et al., they concluded that radiological results and rate of complications of both methods are similar.[23]

Several studies reveal that approximately 30°–40° local angular correction can be obtained by PSO; however double osteotomy is recommended if >40° correction is required.[15,24,25] In the current study, lumbar sagittal plane change was found to be 36.6°±10.6° by means of PSO. Angle of lordosis at the osteotomized level was measured as 30.2°±6.2°. These values show that angular correction at the lumbar sagittal plane was obtained by PSO (p=0.04). The amount of angular correction reported in the literature was similar to our results.[13–15,20]

Early mobilization and high union rates can be achieved with stable fixation after PSO. Clinical studies have shown that the most stable fixation is obtained by combination of transpedicular screw and rod.[14,19,26] In our series, pedicle screw-rod fixation was performed after PSO, and no problems related to fixation or the implants occurred. Junctional kyphosis occurred in only 1 patient, and it was revised by lengthening the instrumentation to the sacrum.

Debarge et al. reported that pelvic parameters of their patients with AS changed significantly after the osteotomies.[24] Conversely, we could not achieve significant improvements in the pelvic parameters of our patients by using PSO (p=0.75, p=0.84, and p=0.96, respectively). However, lumbar lordosis increased from 6.6°±13.7 to 43.8°±8.4° (p<0.0001). These results are similar to those reported in the literature.[14,15,19,20,24,25] In a study regarding pelvic parameters by Roussouly et al., they reported that pelvic retroversion occurred as compensation to rigid lumbar kyphosis. This retroversion results in decrease in the sacral slope and increase in the pelvic tilt. In advanced cases of AS, because the mechanism of compensation becomes insufficient, knee flexion is usually required for forward vision.[16] In patients with advanced AS, compensation is usually not possible due to lumbopelvic spontaneous fusion. Because the levels of osteotomies were between the L1 and L4 vertebrae in our study, improvement in lumbar lordosis but not pelvic parameters can be explained by the spontaneous fusions at the sacropelvic junctions. In the literature, the level of the osteotomies is recommended to be between the L1 and L4 vertebrae.[14,15,23–25] In the current study, mean CSVL decreased from 19.7±9.7 cm to 7.45±3.8 cm after the osteotomies (p=0.005). In a study by Arun et al., mean CSVL decreased from 14.5 cm preoperatively to 5.5 cm postoperatively.[14]

Kiaer et al. evaluated the clinical results of their patients by using ODI and SF-36 and found that the results significantly improved after the surgeries.[19] Mean ODI value of our patients at final follow-up was 30.16±9.7 points, similar to the results of Kiaer et al.

Mean SF-36 mental score reported by Kiaer et al. was approximately the same as in the normal population.[19] This was 41.2±9.9 in our study, which is similar to the mean SF-36 score of the normal population. However, mean SF-36 physical function score was 35.3±7.1, which is significantly lower than the mean score of the normal population. Whereas limited physical functioning in these patients resulted from the AS disease itself, mental and physical functioning scores significantly improved after the osteotomies.

We conclude that in patients with severe rigid sagittal plane spine deformities due to ankylosing spondylitis, lumbar lordosis and sagittal balance can be obtained by pedicle subtraction osteotomy performed on the lumbar region.

Conflics of Interest: No conflicts declared.

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