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*Case Series*

# Clinical and Radiographic Outcomes of Surgical Correction of Kyphotic Spinal Deformity in Patients with Ankylosing Spondylitis: A Retrospective Case Series

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## Abstract

Ankylosing spondylitis is a chronic inflammatory disease of the axial skeleton that, in some patients, leads to the development of rigid kyphotic spinal deformity, significant functional limitations, and the need for surgical correction.

Objective. To evaluate the clinical and radiographic outcomes of surgical correction of kyphotic spinal deformity in patients with ankylosing spondylitis.

Methods. A retrospective, single-center case series study was conducted. The analysis included 13 patients with ankylosing spondylitis and kyphotic spinal deformity who underwent surgery between 2017 and 2025. The median age was 41 [36; 49] years; 10 were men (76.9%) and 3 were women (23.1%). All patients underwent posterior surgical correction involving spinal osteotomies, transpedicular fixation, and posterior spondylodesis. The angle of kyphotic deformity, BASDAI and BASFI indices, pain intensity on a visual analog scale, and the frequency of complications were assessed. The follow-up period was 12 months.

Results. After 12 months, the median angle of kyphotic deformity decreased from 78.0 [71.1; 86.7]° to 38.0 [33.2; 43.7]°; the median relative correction was 49.6 [46.7; 58.0]%, and the mean percentage of correction was 53.0±13.9%. The median BASDAI score decreased

from 4.5 [4.0; 5.3] to 1.4 [1.2; 1.5] points, BASFI from 5.1 [4.4; 5.8] to 1.3 [1.2; 1.5] points, and VAS from 6 [5; 7] to 3 [2; 3] points. For all of these indicators, the differences between the preoperative and postoperative periods were statistically significant ($p<0.001$). Mechanical complications were recorded in 2 of 13 patients (15.4%); in both cases, repeat surgical intervention was required.

Conclusion. In this series of cases, surgical correction of kyphotic spinal deformity in patients with ankylosing spondylitis was accompanied by a marked reduction in the angle of deformity and improvement in clinical and functional parameters 12 months after surgery. However, the risk of mechanical complications necessitates an individualized approach to determining the extent of correction and the fixation strategy.

**Keywords:** ankylosing spondylitis, kyphotic spinal deformity, spinal osteotomy, transpedicular fixation, BASDAI, BASFI.

## 1. Introduction

Ankylosing spondylitis is a chronic inflammatory disease that primarily affects the axial skeleton and leads to progressive restriction of spinal mobility. As the disease progresses, some patients develop pronounced fixed deformities accompanied by a disruption of the sagittal profile, chronic pain, reduced functional activity, and a decline in quality of life [1].

In cases of rigid kyphotic deformity, conservative treatment is unable to correct the established structural changes. In these cases, surgical correction becomes the primary treatment method, aimed at reducing the deformity, improving the trunk's spatial alignment, and enhancing the patient's daily activity. However, such procedures remain technically complex and are associated with the risk of mechanical and neurological complications, especially when multilevel correction and extensive fixation are required [2,3].

Despite extensive experience with various types of spinal osteotomies, the outcomes of surgical treatment for patients with ankylosing spondylitis continue to depend on the initial severity of the deformity, the extent of the procedure, and the specifics of the fixation technique. In this regard, an analysis of our own clinical and radiographic outcomes is of practical interest [1,4-6].

The aim of the study is to evaluate the clinical and radiographic outcomes of surgical correction of kyphotic spinal deformity in patients with ankylosing spondylitis.

## 2. Materials and methods

A retrospective, single-center case series study was conducted. The analysis included 13 patients with ankylosing spondylitis and severe kyphotic spinal deformity who underwent surgical treatment between 2017 and 2025. The study included patients for whom complete clinical and radiographic data were available prior to surgery and 12 months after the procedure.

Among the included patients were 10 men and 3 women. The median age at the time of surgery was 41 [36; 49] years, and the median duration of the disease was 9 [7; 11] years. The preoperative median angle of kyphotic deformity was 78.0° [71.1°; 86.7°].

In all cases, a posterior surgical approach was used, involving corrective spinal osteotomies, transpedicular fixation, and posterior spondylodesis. The surgical strategy was determined individually based on the severity and rigidity of the deformity. Ponte osteotomies, pedicular subtraction osteotomies, and Smith–Petersen osteotomies were performed both as isolated procedures and in combination. Isolated procedures were performed in 7 of 13 patients, and combined osteotomy techniques in 6 of 13.

The primary outcomes assessed were radiographic and clinical parameters. Radiographic parameters included the angle of kyphotic deformity before surgery and 12 months after surgery, as well as the percentage of deformity correction. Clinical indicators included the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), the Bath Ankylosing Spondylitis Functional Index (BASFI), and pain intensity on a visual analog scale (VAS, 0–10 points). The presence of complications and the need for repeat surgeries were also analyzed.

Statistical analysis was performed based on data from individual observations. Due to the small sample size, quantitative indicators are presented primarily as the median and interquartile range [Q1; Q3]. To describe certain parameters, mean values and standard deviations are additionally provided.

The Wilcoxon signed-rank test was used to compare preoperative and postoperative indicators. Categorical data are presented as absolute values and percentages. Differences were considered statistically significant at $p<0.05$.

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## 3. Results

The study included 13 patients with ankylosing spondylitis and fixed kyphotic spinal deformity. Men accounted for 76.9% of the sample. The median age was 41 [36; 49] years, and the median duration of the disease was 9 [7; 11] years. The preoperative severity of the deformity was significant: the median kyphosis angle reached 78.0 [71.1; 86.7]°, with a range from 49.0° to 105.0° (Table 1).

Surgical correction was performed using various osteotomy techniques (Table 2). The most frequently used procedures involved the Ponte osteotomy—either as a standalone procedure or in combination with other methods. Isolated Ponte osteotomy was performed in 5 patients, isolated pedicle subtraction osteotomy in 1 patient, and Smith–Petersen osteotomy in 1 patient. Combined osteotomy techniques were used in 6 patients.

*Table 1 - Baseline demographic and clinical characteristics of 13 patients with AS*

| ID | Gender | Age (years) | Duration of AS (years) | Preoperative kyphosis (°)) | Preoperative BASDAI | Preoperative BASFI | VAS (0–10) |
|---|---|---|---|---|---|---|---|
| 1 | M | 33 | 7 | 105 | 3,0 | 4,4 | 5 |
| 2 | M | 60 | 15 | 87,5 | 6,5 | 5,0 | 7 |
| 3 | F | 41 | 10 | 74 | 4,0 | 4,3 | 6 |
| 4 | M | 50 | 13 | 71,1 | 5,0 | 6,5 | 5 |
| 5 | M | 35 | 7 | 78 | 3,0 | 5,1 | 7 |
| 6 | M | 49 | 9 | 68,3 | 4,0 | 3,5 | 4 |
| 7 | M | 48 | 7 | 82 | 5,3 | 4,0 | 6 |
| 8 | M | 44 | 8 | 64,6 | 6,3 | 5,1 | 5 |
| 9 | M | 36 | 8 | 86,7 | 5,8 | 4,8 | 7 |
| 10 | M | 37 | 9 | 79,3 | 4,5 | 5,8 | 5 |
| 11 | F | 32 | 7 | 73,4 | 4,0 | 6,0 | 4 |
| 12 | M | 40 | 11 | 89,9 | 3,0 | 5,2 | 6 |
| 13 | F | 59 | 14 | 49 | 5,0 | 6,7 | 7 |
| Median (IQR) | | 41 (35–49) | 9 | 78,0 (71,1–86,7) | 5,0 (4,0–5,8) | 5,1 (4,4–5,8) | 6 (5–7) |

Twelve months after surgery, marked radiographic improvement was observed. The median angle of kyphotic deformity decreased from 78.0° [71.1°; 86.7°] to 38.0° [33.2°; 43.7°] ($p<0.001$). The mean absolute reduction in angle was 40.7±11.4°, and the median relative correction was 49.6% [46.7%; 58.0%]. The mean percentage of correction was 53.0±13.9%.

*Table 2 - Surgical procedures, postoperative outcomes, and complications*

| ID | Type of Osteotomy | Levels | Postoperative Kyphosis (°) | Correction (%) | Postoperative BASDAI | Postoperative BASFI | Postoperative VAS | Follow-up (months) | Complications | Revision |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PSO + SPO | Th7, Th10 L1-L2 | 46 | 56,2 | 2,0 | 1,3 | 2 | 12 | Screw loosening | Yes (removal)) |
| 2 | Ponte | Th11-Th12 | 45,2 | 48,3 | 1,5 | 1,5 | 3 | 12 | No | No |
| 3 | Ponte + PSO | Th9-L4, Th7-Th8 | 43 | 41,9 | 1,2 | 1,2 | 3 | 12 | No | No |
| 4 | PSO | Th8 | 35,8 | 49,6 | 1,3 | 1,7 | 3 | 12 | No | No |
| 5 | Ponte + PSO | Th9-L4, Th9 | 39,4 | 49,5 | 1,0 | 1,3 | 3 | 12 | No | No |
| 6 | Ponte | Th12-L5 | 33,2 | 51,4 | 1,5 | 0,8 | 2 | 12 | No | No |
| 7 | PSO + SPO | Th9, L2, Th6-Th7 | 43,7 | 46,7 | 1,4 | 1,1 | 4 | 12 | No | No |

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*Table 2 (Continuation) - Surgical procedures, postoperative outcomes, and complications*

| ID | Type of Osteotomy | Levels | Postoperative Kyphosis (°) | Correction (%) | Postoperative BASDAI | Postoperative BASFI | Postoperative VAS | Follow-up (months) | Complications | Revision |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Ponte | Th4-Th11 | 38 | 41,2 | 1,7 | 1,4 | 3 | 12 | No | No |
| 9 | PSO + Ponte | Th8-Th9, Th11-L5 | 61,7 | 28,8 | 1,6 | 0,9 | 4 | 12 | No | No |
| 10 | PSO + Ponte | Th8, Th3-L3 | 18,4 | 76,8 | 0,8 | 2,1 | 2 | 12 | No | No |
| 11 | Ponte | Th7-L3 | 30,8 | 58,0 | 1,3 | 1,5 | 2 | 12 | No | No |
| 12 | Ponte | Th12-L1, L2-L4 | 35,1 | 60,9 | 0,9 | 1,3 | 4 | 12 | No | No |
| 13 | Smit Petersen Petersen | L5-S1 (decompression pression)) | 10 | 79,6 | 1,4 | 1,9 | 3 | 12 | Screw fracture | Yes (removal) |
| Median (IQR) | | | 38,0 (33,2–43,7) | 53,8 (45,1–62,3) | 1,3 (1,2–1,5) | 1,3 (1,1–1,7) | 3 (2–4) | 12 | 2/13 (15,4%) | 2/13 (15,4%) |

Positive changes in clinical and functional parameters were also observed following surgical treatment. The median BASDAI decreased from 4.5 [4.0; 5.3] to 1.4 [1.2; 1.5] points ($p<0.001$), and the median BASFI score from 5.1 [4.4; 5.8] to 1.3 [1.2; 1.5] points ($p<0.001$). Pain intensity on the VAS decreased from 6 [5; 7] to 3 [2; 3] points ($p<0.001$). Thus, following surgery, not only was a reduction in deformity observed, but also an improvement in functional status and a reduction in pain.

Complications were reported in 2 of 13 patients, representing 15.4%. In both cases, the complications were mechanical in nature. In one patient, loosening of the fixation components was detected, requiring revision surgery with cement augmentation. In the other patient, a screw fracture occurred, necessitating a repeat surgical procedure with removal of the metal implant. No other complications were reported during the 12-month follow-up period in this series.

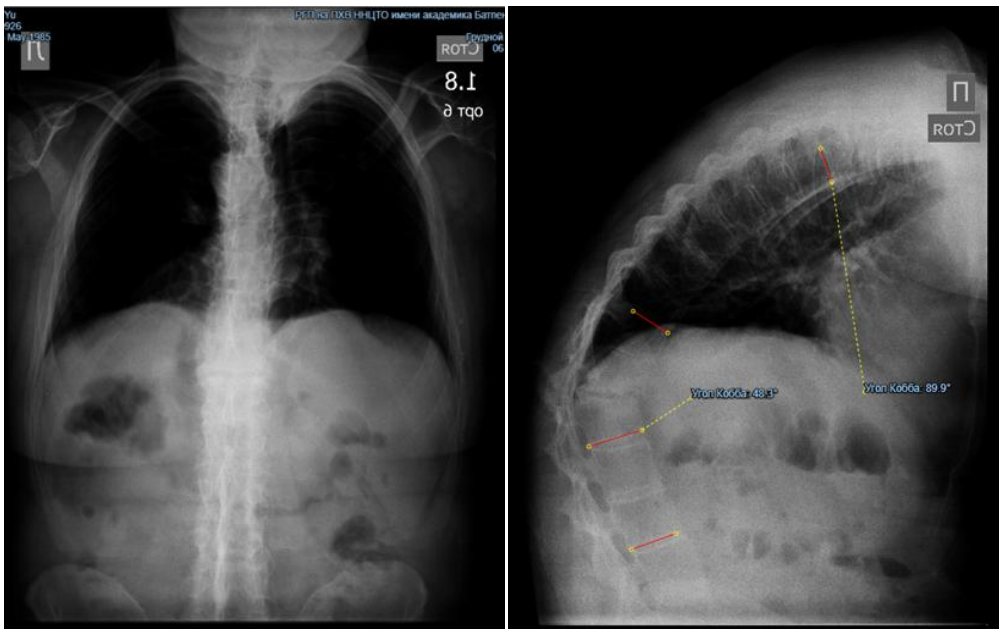


*Figure 1 - Anteroposterior and lateral radiographs showing marked kyphotic deformity of the thoracic spine in a patient with ankylosing spondyloarthritis*

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*Figure 2 - Complications in the early postoperative period in a patient with ankylosing spondyloarthritis (1 day after surgery)*

A radiographic examination of the thoracic spine in the anteroposterior and lateral views revealed marked kyphotic deformity (Figure 1). According to the lateral X-ray, the degree of thoracic kyphosis, measured using the Cobb method between the endplates of vertebrae Th4–Th12, was 89.9°, which corresponds to severe hyperkyphosis (Figure 2).

## 4. Discussion

The data obtained indicate that surgical correction of kyphotic spinal deformity in patients with ankylosing spondylitis in this case series was associated with a marked reduction in the angle of deformity and an improvement in clinical and functional parameters 12 months after surgery. After the procedure, the median kyphosis angle decreased by approximately half, and the BASDAI, BASFI, and VAS scores demonstrated statistically significant positive trends.

From a clinical standpoint, the combined improvement in radiographic and functional outcomes appears to be the most important. A decrease in BASFI reflects a reduction in limitations in daily activities, whereas a decrease in VAS indicates a reduction in pain following the restoration of a more physiological trunk position. A decrease in BASDAI also indicates a favorable trend in patients' condition; however, this indicator should be interpreted with caution, as it

reflects not only the mechanical consequences of the deformity but also the overall disease activity.

It should be emphasized that the surgical approach in this series was not standardized. Both isolated and combined osteotomy techniques were used, reflecting an individualized approach to treating patients with varying degrees of severity and extent of deformity. For this reason, the presented results should be viewed as an overall assessment of the effectiveness of surgical correction as a whole, rather than as a comparative analysis of individual techniques.

The complication profile deserves special attention. Mechanical complications occurred in 15.4% of patients and, in both cases, required repeat surgical intervention. This indicates that even when significant correction of the deformity is achieved, the stability of fixation remains a critically important factor in postoperative success. It is likely that the risk of such complications increases in patients with poor bone quality, with extensive fixation, and with high loads on the distal supporting elements of the construct.

Overall, the results of this study suggest that surgical correction is an effective treatment for severe kyphotic spinal deformity in patients with ankylosing spondylitis. However, the data presented do not support overly broad generalizations and underscore the need for cautious interpretation of the observed outcomes.

*Limitations of the Study*

This study has several limitations. First and foremost, the sample size was small, which limits the statistical power of the analysis and prevents meaningful intergroup comparisons. The study was retrospective and single-center in nature, which increases the risk of selection bias and limits the generalizability of the results.

A significant limitation is the heterogeneity of surgical interventions: the study included patients who underwent various types of osteotomies, both as isolated procedures and in combination. Therefore, the data obtained do not allow conclusions to be drawn regarding the advantages of any specific technique. Furthermore, the follow-up period was 12 months, which is insufficient to assess the durability of the correction and late complications.

Another limitation is the set of parameters evaluated. The study analyzed the angle of kyphotic deformity, BASDAI, BASFI, and VAS, but did not conduct a systematic assessment of global sagittal balance parameters. Furthermore, bone mineral density was not assessed in a standardized manner across the entire cohort; therefore, a possible association between bone quality and mechanical complications in this series can only be considered a clinical hypothesis.

## 5. Conclusions

In this retrospective case series, surgical correction of kyphotic spinal deformity in patients with ankylosing spondylitis resulted in a significant reduction in the angle of deformity and was accompanied by an improvement in clinical and functional outcomes 12 months after surgery. Mechanical complications were reported in 15.4% of patients and, in some cases, required reoperation. The results confirm the promise of surgical correction in this patient population but underscore the need for individualized planning of the extent of osteotomy and fixation strategy.

**Conflict of interests.** The authors declare no conflict of interest

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**Author contributions.** Conceptualization – S.A.; Patient care and clinical data collection – K.A., A.S.; Methodology – D.Y., J.A.; Data curation – S.S., D.B.; Formal analysis - D.Y., J.A.; Literature review – K.A., J.A.; Visualization – B.T.; Writing – original draft – K.A., D.Y.; Writing – review and editing – S.A., K.K.

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## Анкилоздаушы спондилоартрит кезіндегі кифоздық деформацияны хирургиялық түзетудің клиникалық-рентгенологиялық нәтижелері: Клиникалық жағдайлардың ретроспективті сериясы

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### Түйіндеме

Анкилоздаушы спондилоартрит (АС) – осьтік қаңқаның созылмалы қабыну ауруы, ол омыртқада анкилоздардың қалыптасуына және айқын кифотикалық деформациялардың дамуына әкеледі. Биологиялық терапияның жетістіктеріне қарамастан, кейбір науқастарда ауыр функционалдық шектеулермен қатар жүретін және хирургиялық түзетуді талап ететін бекітілген деформациялар дамиды.

Зерттеудің мақсаты. Айқын кифотикалық омыртқа деформациясымен асқынған анкилоздаушы спондилоартриті бар науқастарды хирургиялық емдеудің клиникалық-рентгенологиялық нәтижелерін бағалау.

Әдістері. Зерттеуге 2017–2025 жылдары ем алған АС бар 13 науқас (10 ер адам және 3 әйел), орташа жасы 44,1±14 жыл, енгізілді. Омыртқаның түзетуші остеотомиялары (педикулярлық субтракциялық, Понте, Смит–Петерсен әдістері бойынша) транспедикулярлық фиксациямен және артқы спондилодезбен орындалды. Тиімділік BASDAI және BASFI шкалалары, кифотикалық деформация бұрышының шамасы және асқынулар жиілігі бойынша бағаланды.

Нәтижелері. Отадан кейін функционалдық көрсеткіштердің статистикалық тұрғыдан мәнді жақсаруы байқалды: BASDAI 5,1-ден 1,3 баллға дейін, BASFI 5,4-тен 1,76 баллға дейін төмендеді. Кифотикалық деформацияны түзетудің орташа пайызы 53,8% құрады, бұрыштың абсолютті орташа азаюы – 36,4°. Негізінен

сүйек тінінің остеопороздық өзгерістері аясында фиксация элементтерінің тұрақсыздығымен байланысты механикалық асқынулар тіркелді.

Қорытынды. Транспедикулярлық фиксациямен үйлескен түзетуші остеотомиялар сагитталды теңгерімді қалпына келтірудің және АС бар науқастардың клиникалық-функционалдық жағдайын жақсартудың тиімді әдісі болып табылады. Сүйек минералдық тығыздығын отаға дейін бағалау және хирургиялық тактиканы дараландыру операциядан кейінгі асқынулар қаупін төмендетудің негізгі факторлары болып табылады.

**Түйінді сөздер:** анкилоздаушы спондилоартрит, хирургиялық емдеу, остеотомия, функционалдық нәтижелер.

# Клинико-рентгенологические результаты хирургической коррекции кифотической деформации при анкилозирующим спондилоартрите: Ретроспективная серия клинических случаев

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## Резюме

Анкилозирующий спондилоартрит (АС) – хроническое воспалительное заболевание осевого скелета, приводящее к формированию анкилозов и выраженных кифотических деформаций позвоночника. Несмотря на успехи биологической терапии, у части пациентов развиваются фиксированные деформации, сопровождающиеся тяжелыми функциональными ограничениями и требующие хирургической коррекции.

Цель исследования: оценить клинико-рентгенологические результаты хирургического лечения пациентов с анкилозирующим спондилоартритом, осложнённым выраженной кифотической деформацией позвоночника.

Методы. В исследование включены 13 пациентов с АС (10 мужчин и 3 женщины), средний возраст 44,1±14 лет, проходивших лечение в 2017–2025 гг. Выполнялись корригирующие остеотомии позвоночника (педикулярные субтракционные, по Понте, по Смит-Петерсону) с транспедикулярной фиксацией и задним спондилодезом. Эффективность оценивалась по шкалам BASDAI и BASFI, величине угла кифотической деформации и частоте осложнений.

Результаты. Послеоперационно отмечено статистически значимое улучшение функциональных показателей: BASDAI снизился с 5,1 до 1,3 балла, BASFI – с 5,4 до 1,76 балла. Средний процент коррекции кифотической деформации составил 53,8%, абсолютное среднее уменьшение угла – 36,4°. Зарегистрированы механические осложнения, связанные преимущественно с нестабильностью элементов фиксации на фоне остеопоротических изменений костной ткани.

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Выводы. Корригирующие остеотомии в сочетании с транспедикулярной фиксацией являются эффективным методом восстановления сагиттального баланса и улучшения клинико-функционального состояния пациентов с АС. Предоперационная оценка минеральной плотности кости и индивидуализация хирургической тактики являются ключевыми факторами снижения риска послеоперационных осложнений.

**Ключевые слова:** анкилозирующий спондилоартрит, хирургическое лечение, остеотомия, функциональные результаты.

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