Treatment of Andersson lesion-complicating ankylosing spondylitis via early minimally invasive surgery

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Aims

A variety of surgical methods and strategies have been demonstrated for Andersson lesion (AL) therapy. In 2011, we proposed and identified the feasibility of stabilizing the spine without curettaging the vertebral or discovertebral lesion to cure non-kyphotic AL. Additionally, due to the excellent reunion ability of ankylosing spondylitis, we further came up with minimally invasive spinal surgery (MIS) to avoid the need for both bone graft and lesion curettage in AL surgery. However, there is a paucity of research into the comparison between open spinal fusion (OSF) and early MIS in the treatment of AL. The purpose of this study was to investigate and compare the clinical outcomes and radiological evaluation of our early MIS approach and OSF for AL.

Methods

A total of 39 patients diagnosed with AL who underwent surgery from January 2004 to December 2022 were retrospectively screened for eligibility. Patients with AL were divided into an MIS group and an OSF group. The primary outcomes were union of the lesion on radiograph and CT, as well as the visual analogue scale (VAS) and Oswestry Disability Index (ODI) scores immediately after surgery, and at the follow-up (mean 29 months (standard error (SE) 9)). The secondary outcomes were total blood loss during surgery, operating time, and improvement in the radiological parameters: global and local kyphosis, sagittal vertical axis, sagittal alignment, and chin-brow vertical angle immediately after surgery and at the follow-up.

Results

Data for 30 patients with AL were evaluated: 14 in the MIS group and 16 in the OSF group. All patients were followed up after surgery; no nonunion complications or instrumentation failures were observed in either group. No significant differences in the VAS and ODI scores were identified between the two groups. Mean ODI improved from 51 (SE 5) to 17 (SE 5) in the MIS group and from 52 (SE 6) to 19 (SE 5) in the OSF group at the follow-up. There were significant improvements in total blood loss ($p = 0.025$) and operating time ($p < 0.001$) between the groups. There was also no significant difference in local kyphosis six months postoperatively ($p = 0.119$).

Conclusion

Early MIS is an effective treatment for AL. MIS provides comparable clinical outcomes to those treated with OSF, with less total blood loss and shorter operating time. Our results support and identify the feasibility of solid immobilization achieved by posterior instrumentation without bone graft via MIS for the treatment of AL.

Take home message

- This study proposed and identified the feasibility of stabilize the spine other than to curettage the vertebral or discovertebral lesion and bone graft to cure Andersson lesion (AL).
- Early minimally invasive surgery is an effective treatment for AL which provide

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comparable clinical outcomes to those with open spinal fusion, with less total blood loss and shorter operating time.

Introduction

Andersson lesions (AL) were first reported in 1937.[1] This lesion is a localized vertebral or discovertebral lesion associated with ankylosing spondylitis.[2] Both inflammatory and mechanical factors are involved in the lesion's origin and development.[3] Because of the large variability in the pathogenesis and clinical characteristics of AL compared with those of conventional spinal fractures, AL is difficult to treat. Inflammatory AL may be the natural progression of ankylosing spondylitis, which can be effectively treated conservatively, while traumatic AL is characterized by true spinal pseudarthrosis and often requires fixation and fusion surgery when conservative treatment fails.[3-7] Early physiology in AL shows lymphocytic inflammation, pressure-induced destruction, and reactive new bone formation, which further suggests that mechanical stress may be the initiating factor.[6] Based on this finding, in 2011, we proposed that it was more important to stabilize the spine rather than to perform curettage of the vertebral or discovertebral lesion.[8] However, this approach was quite different from curettage, whether an anterior,[9] posterior,[10] or combined anterior and posterior approach[11] was used.[8] Open spinal fusion (OSF) without lesion curettage resolved AL in a previous study with favourable long-term follow-up outcomes.[8] Several other studies confirmed these results, supporting the safety and efficacy of not performing curettage.[12-14]

Based on previous studies and our pathological findings of bone formation in AL (Supplementary Figure a) indicating the excellent reunion ability of ankylosing spondylitis,[8,12] we further hypothesized that solid immobilization achieved solely by posterior instrumentation may be not only sufficient but crucial in the treatment of AL. We proposed that minimally invasive spinal surgery (MIS) without bone grafting could be effective to treat AL without necessity of kyphosis correction, as with OSF.[2,15-17] Therefore, in this study, we reviewed the clinical records of 14 AL patients who underwent MIS and 16 AL patients who underwent OSF to compare the efficacy of these two approaches.

Methods

Permission to conduct this prospective study was obtained from the ethics committee of Shandong Provincial Hospital Affiliated to Shandong First Medical University, China. Written informed consent was obtained from all participants. The inclusion criteria were as follows: 1) patients diagnosed with ankylosing spondylitis combined with AL; 2) no effective relief of chest and back pain after conservative treatment; and 3) complete clinical data. The exclusion criteria consisted of other types of spinal fracture without ankylosing spondylitis, and spinal tumours. Between January 2004 and December 2022, 39 patients were admitted to the authors' hospital for AL associated with ankylosing spondylitis. Of these patients, 30 AL without necessity of kyphosis correction were included in the study; 16 patients underwent posterior OSF without lesion curettage, and 14 patients underwent MIS (Supplementary Figure b) without either bone grafting or lesion curettage. The other nine patients were excluded from the study; two cases had neurological deficits and seven cases had kyphotic AL with need for kyphosis correction.

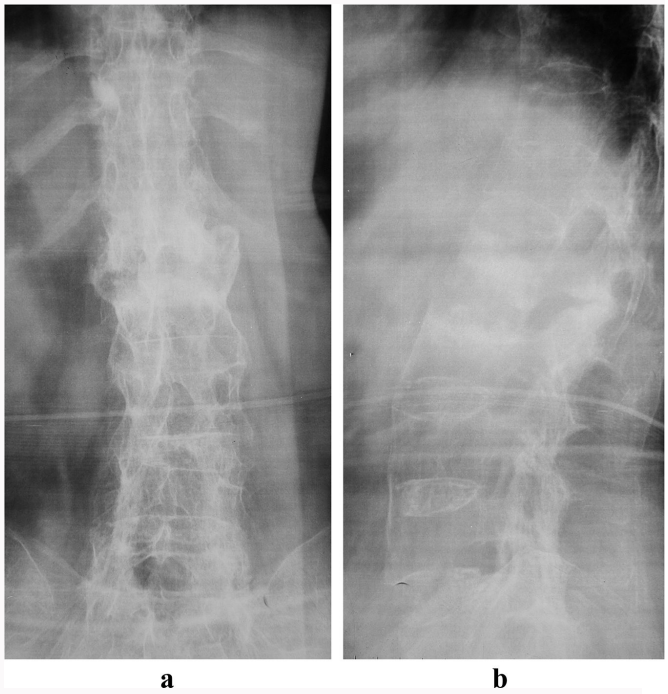

Fig. 1
a) Preoperative anteroposterior and b) lateral radiographs of a 42-year-old female patient from the open spinal fusion group who had an Andersson lesion at L1/2. There is a 9° local kyphosis.

The patients' basic information was recorded, namely age, sex, height, weight, and follow-up time. A detailed history was recorded, and a physical examination was performed for each patient preoperatively. Human leucocyte antigen B27, ESR, and CRP concentration were also obtained.

Radiological measurements

Standing anteroposterior and lateral radiographs were obtained preoperatively, postoperatively, and at the follow-up. Several radiological parameters were measured on the lateral view: level of the AL, local kyphosis, global kyphosis, sagittal vertical axis, proximal thoracic kyphosis, thoracic kyphosis, thoracolumbar kyphosis, lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope, and chin-brow vertical angle (CBVA).

MRI and CT were performed to evaluate the degree of destruction in the lesion and the condition of the spinal canal. Radiographs and CT were also performed to assess the healing of the lesion at the follow-up.

Surgical method

Although there was focal kyphosis in several cases, there was no evidence of global kyphosis or imbalance. The overall sagittal plane alignment and balance were within normal parameters. Given the patients' cervical-occipital vertical angle and cervical spine range of motion, osteotomy intervention was deemed unnecessary. Therefore, two surgical techniques without osteotomy were used in this study: posterior OSF without lesion curettage (Figure 1, Supplementary Figures c and d, and Figure 2) and 2) posterior MIS without bone grafting or lesion curettage (Figure 3, Supplementary Figure e, and Figure 4). Because there are no established guidelines for the surgical treatment of AL, we divided the patients alternatively, as follows: 14 cases underwent MIS, and 16 cases

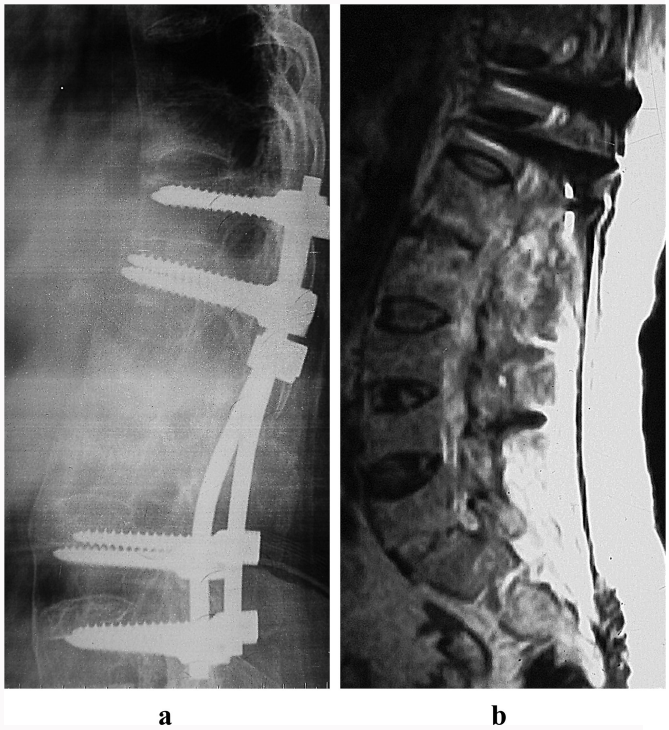

Fig. 2
The same patient as shown in Figure 1. a) The anterior lesion is healed on the on the lateral radiograph film at two-year follow-up. b) MRI of six-year follow-up showed the anterior lesion remained healed with no complications.

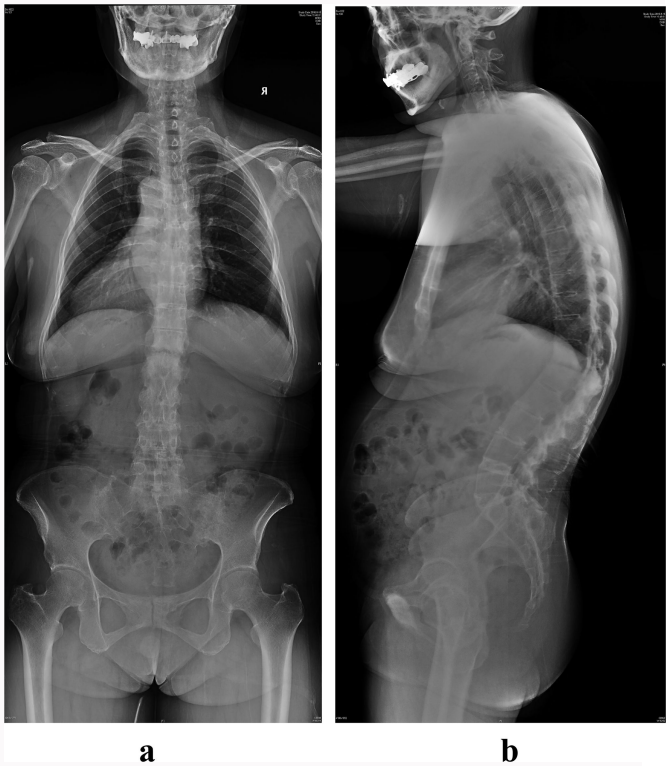

Fig. 3
a) Preoperative anteroposterior and b) lateral radiographs of a 56-year-old female patient from the minimally invasive surgery group who had an Andersson lesion at T12/L1. There is a 31° local kyphosis.

underwent OSF. Surgical information was recorded, including operating time, total blood loss (TBL), and the number of instrumented segments.

Evaluation of quality of life

A visual analogue scale (VAS) was used to evaluate back pain, and the Oswestry Disability Index (ODI)[18] was used to assess the clinical outcomes. Postoperative complications were also recorded, such as surgical site infection (SSI), pseudarthrosis, instrumentation failure, and nerve injury.

Evaluation of bone fusion

The most important efficacy variable was bone fusion assessment with radiography at 12 months after surgery. Due to the unique nature of AL, there is no bone grafting in the anterior bone defect area, thus, no fully established method exists for bone fusion assessment. However, we have referenced the classic Bridwell[19] and Brantigan[20] grading methods. We considered fusion to be achieved when bone trabeculae grew to adjacent endplates without any obvious gap, there was no pseudarthrosis formation, and no internal fixation breakage. Conversely, non-fusion was determined if these criteria were not met.

Patients' clinical data

A total of 30 consecutive AL cases were included between January 2004 and December 2022: 14 cases in the MIS group and 16 cases in the OSF group. All patients underwent surgical treatment by the same surgeon (JS) in a university-affiliated hospital, Shandong Provincial Hospital. All surgeries, including MIS and OSF, were performed through a posterior approach.

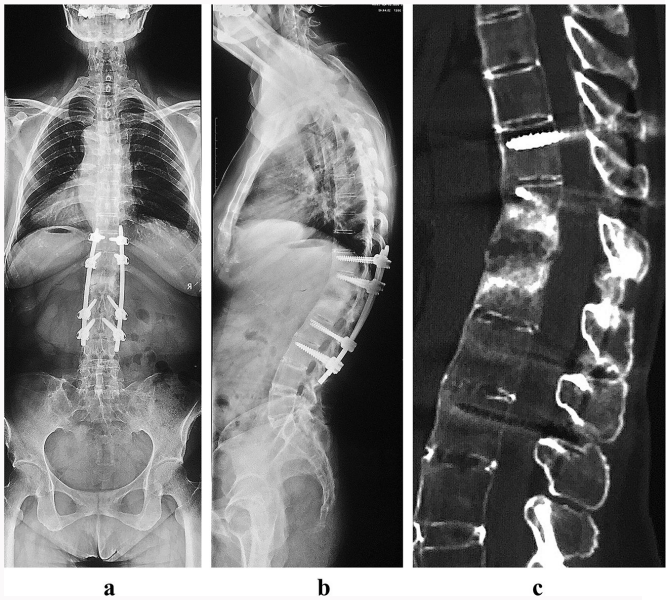

Fig. 4
a) Anteroposterior and b) lateral radiographs at the final one-year follow-up showed nonunion or pseudoarthrosis. c) The anterior lesion is united on the CT at the final follow-up.

There were 21 males and nine females with a mean age of 45 years (standard error (SE) 9, 23 to 62). The mean follow-up time was 29 months (SE 9, 12 to 48), with no significant difference between the groups ($p > 0.05$). Of the 30 AL cases, seven were Cawley type I and 23 were Cawley type III. All AL were located

Table I. Clinical and radiological information of Andersson Lesion patients.

Patients	Group	Sex	Age, yrs	Level of AL	TBL, ml	OT, mins	ODI		VAS		Local kyphosis, °	
							Preop	Final follow-up	Preop	Final follow-up	Preop	Final follow-up
1	OSF	F	42	L1/2	750	312	60	14	6	2	9	9
2	OSF	M	53	T12/L1	800	280	46	22	5	2	15	16
3	OSF	F	41	L5/S1	500	301	52	18	6	2	-33	-36
4	MIS	M	36	T12/L1	110	120	54	16	7	2	15	17
5	OSF	M	50	T9/10	520	340	48	24	4	2	11	5
6	OSF	M	62	T12/L1	680	300	56	16	5	1	16	13
7	OSF	M	43	T11	490	180	62	20	7	2	0	0
8	OSF	M	23	L2/3	400	160	46	14	5	1	9	5
9	MIS	M	40	T10/11	280	460	54	12	6	1	19	7
10	MIS	M	31	T11/12	100	240	56	26	5	2	31	21
11	MIS	F	56	T12/L1	180	300	52	20	7	3	31	24
12	MIS	F	40	T10	145	120	48	16	5	1	19	13
13	MIS	M	46	T12	150	140	52	12	4	2	20	7
14	OSF	M	41	L1/2	520	260	48	28	6	3	32	13
15	MIS	M	50	T10/11	250	140	44	20	5	2	24	22
16	OSF	M	33	T8/9	410	190	49	26	4	1	28	26
17	OSF	F	37	T12/L1	520	500	50	27	6	2	24	9
18	MIS	M	37	T9/10	200	200	49	25	6	1	32	29
19	OSF	M	53	T11/12	600	250	50	13	6	1	29	26
20	OSF	M	57	T10/11	560	200	64	15	7	1	28	23
21	OSF	M	46	L2/3	500	500	49	24	7	2	0	-7
22	MIS	F	54	T11/12	250	240	40	20	4	2	30	17
23	MIS	M	51	T11	180	160	48	11	5	1	22	6
24	MIS	F	54	T12/L1	200	210	54	18	7	2	35	22
25	OSF	M	52	T12/L1	500	240	60	16	7	3	21	-7
26	MIS	M	36	T11/12	150	160	54	15	6	2	14	13
27	OSF	M	43	T11/12	500	260	50	12	6	1	40	23
28	MIS	F	40	T11/12	180	180	60	10	7	2	18	13
29	MIS	M	36	T12	140	150	54	11	6	1	24	7
30	OSF	F	54	T12/L1	700	260	48	18	6	2	17	13

AL, Andersson lesion; MIS, minimally invasive surgery; ODI, Oswestry Disability Index; OSF, open spinal fusion; OT, operating time; TBL, total blood loss; VAS, visual analogue scale.

in the thoracolumbar spine except for one case in the OSF group, with a lesion located at L5/S1. The patients' detailed demographic information is shown in Table I.

Statistical analysis

One author (CZ), as a blinded independent observer, completed the postoperative evaluations. Statistical data were analyzed using the Statistical Package for Social Sciences v. 20 software (IBM, USA). Values are presented as mean and standard error (SE). VAS scores, ODI scores, and radiological parameters for the MIS and OSF groups were examined. Differences between the groups were compared with the independent-samples *t*-test (continous data, normal distribution) or chi-squared test (demographic data, VAS scores, ODI scores, and radiological parameters); Fisher's exact test was used to assess the differences in fusion rate between the groups. Patients who died during the follow-up were treated as censored. A p-value < 0.05 was considered statistically significant.

Table II. Comparison of surgical information and clinical outcome between two groups.

Outcome	MIS	OSF	p-value*
Mean TBL, ml (SE)	201 (91)	283 (98)	0.025
Mean OT, mins (SE)	187 (68)	559 (116)	< 0.001
Mean ODI (SE)			
Preoperative	51 (5)	52 (6)	0.623
Postoperative	17 (5)	19 (6)	0.255
Final follow-up	17 (5)	19 (5)	0.193
Mean VAS (SE)			
Preoperative	5.7 (1.1)	5.8 (1.0)	0.795
Postoperative	1.9 (0.9)	1.8 (0.7)	0.708
Final follow-up	1.7 (0.6)	1.8 (0.7)	0.882

*Independent-samples *t*-test.
MIS, minimally invasive surgery; ODI, Oswestry Disability Index; OSF, open spinal fusion; OT, operating time; SE, standard error; TBL, total blood loss; VAS, visual analogue scale.

Results

Comparison of operating time and total blood loss

Mean TBL in the MIS group was less than that in the OSF group: 201 ml (SE 91, 100 to 350) versus 283 ml (SE 98, 400 to 800), respectively (p = 0.025, independent-samples *t*-test). The operating time was shorter in the MIS group compared with the OSF group: 187 minutes (SE 68, 120 to 460) versus 559 minutes (SE 116, 160 to 500), respectively (p < 0.001, independent-samples *t*-test). The results of the comparisons between the groups are shown in Table II.

Evaluation of quality of life

Both the MIS group and OSF group achieved favourable clinical outcomes. The ODI was 51 (SE 5 40 to 60) before surgery and 17 (SE 5, 10 to 26) at the final follow-up in the MIS group and 52 (SE 6, 46 to 64) before surgery and 19 (SE 5, 14 to 28) at the final follow-up in the OSF group. The VAS score was 5.7 (SE 1.1, 4 to 7) before surgery and 1.7 (SE 0.6, 1 to 3) at the final follow-up in the MIS group and 5.8 (SE 1.0, 4 to 7) before surgery and 1.8 (SE 0.7, 1 to 3) at the final follow-up in the OSF group. The perioperative ODI and VAS scores are shown in Table II.

Radiological results

All AL cases had local kyphosis except for one case in the OSF group with -33° local lordosis at an L5/S1 lesion. The preoperative local kyphosis angle was 24° (SE 7°, 14° to 32°) in the MIS group and 15° (SE 17°, -33° to 40°) in the OSF group (including the L5/S1 case) (p = 0.094, independent-samples *t*-test). The degree of local kyphosis improved after surgery and was well maintained at the final follow-up in both groups. The patients' perioperative radiological results are shown in Table III.

Bone fusion assessment results from plain radiography

In the plain radiography results, the fusion rate at 12 months was 92.9% (14 subjects) for the MIS group and 100% (16 subjects) for the OSF group, showing no significant difference between groups (p = 0.467, Fisher's exact test). Although one case in the MIS group did not achieve fusion initially at 12 months, fusion was eventually achieved after six months' brace immobilization. At the final follow-up, no pseudarthrosis or nonunion was observed, and no instrumentation failure occurred in either the OSF or MIS group.

Postoperative complications

There was one case of SSI in the OSF group, which was successfully controlled through conventional antibiotic treatment, and bone fusion was not affected. No neurological complications were observed.

Discussion

AL is a localized vertebral or discovertebral destructive lesion.[21] It is a common complication associated with ankylosing spondylitis.[2,22] Park et al[4] reported that 5.3% (33/622) of their ankylosing spondylitis patients had AL. There are two possible aetiologies for AL: inflammatory and mechanical.[23] Dihlmann and Delling[24] divided AL into two types according to the two aetiologies; however, this classification does not apply to all AL cases. Nikolaisen and Nossent[25] investigated the early histology of AL, documenting infiltration with cluster of differentiation 3-positive lymphocytes and immunoglobulin A plasma cells, as well as reactive changes with new bone formation during the development of AL.[25] Currently, a common opinion is that both inflammatory and mechanical factors have roles in the origin and development of AL.[2,26]

Cawley et al[27] further divided AL into three types according to the location of the AL. Type I is localized to the central subchondral portions of the vertebral body. Type II is localized peripherally at the anterior or posterior part of the discovertebral junction. Type III comprises destruction of the entire discovertebral junction of two adjacent vertebral bodies. Among the 30 AL cases included in the present study, 23 were Cawley type III and seven were Cawley type I. One theory explaining the destruction of the vertebral body and intervertebral disc in Cawley type III is that the nuclear material herniates through the endplate into the vertebral body and causes inflammatory destruction owing to its antigenicity.[27]

Bron et al[21] divided AL into three stages according to the degree of lesion destruction as a localized lesion, extensive lesion without fractured posterior elements, and extensive lesion with fractured posterior elements. Rupture of the posterior elements is mainly caused by primary trauma or stress fracture secondary to anterior destruction.[2,6] All 30 cases in this study had ruptured posterior elements, in which rupture of the posterior ligaments was observed in 19 cases, and fracture of the spinous process(es) was observed in 11 cases.

Conventional treatment is effective for the management of AL.[12] Considering the important role of inflammation in the origin and development of ankylosing spondylitis, nonsteroidal anti-inflammatory drugs and anti-tumour necrosis factor-α are commonly used for AL therapy.[28] Park et al[4] reported that patients with Cawley types I and II have excellent responses to anti-inflammatory drugs. The authors emphasized the necessity of distinguishing inflammatory and

Table III. Comparison of perioperative sagittal parameters between two groups.

Mean sagittal parameters, ° (SE)	Preoperative			Postoperative			Final follow-up		
	MIS	OSF	p-value*	MIS	OSF	p-value*	MIS	OSF	p-value*
Local kyphosis	24 (7)	15 (17)	0.094	14 (8)	7 (17)	0.158	16 (7)	8 (16)	0.119
CBVA	12 (9)	12 (4)	0.994	10 (9)	11 (4)	0.797	11 (7)	11 (3)	0.674
SVA	47 (34)	64 (45)	0.253	37 (30)	49 (48)	0.442	38 (27)	49 (47)	0.443
TPA	24 (9)	27 (9)	0.272	22 (8)	21 (6)	0.864	22 (8)	20 (6)	0.527
T1 Spin	-4 (7)	-1 (6)	0.252	-3 (5)	-1 (6)	0.333	-4 (5)	-1 (6)	0.244
PTK	12 (6)	14 (8)	0.543	11 (5)	14 (7)	0.213	12 (3)	14 (6)	0.188
TK	47 (12)	50 (15)	0.548	41 (10)	43 (15)	0.702	44 (10)	43 (15)	0.980
TLK	33 (11)	31 (18)	0.709	27 (10)	21 (14)	0.241	29 (10)	23 (14)	0.186
LL	-36 (8)	-28 (17)	0.110	-36 (9)	-34 (15)	0.565	-33 (10)	-31 (15)	0.677
PI	48 (7)	47 (9)	0.534	49 (7)	47 (8)	0.519	49 (7)	47 (9)	0.600
PT	27 (7)	27 (9)	0.993	25 (6)	23 (5)	0.353	25 (6)	23 (5)	0.464
SS	21 (6)	19 (10)	0.567	23 (5)	24 (10)	0.962	24 (5)	24 (10	0.825

*Independent-samples *t*-test.
CBVA, chin-brow vertical angle; LL, lumbar lordosis; MIS, minimally invasive surgery; OSF, open spinal fusion; PI, pelvic incidence; PT, pelvic tilt; PTK, proximal thoracic kyphosis; SE, standard error; SS, sacral slope; SVA, sagittal vertical axis; TK, thoracic kyphosis; TLK, thoracolumbar kyphosis; TPA, T1 pelvic angle.

traumatic AL because the former responds to conventional treatment, whereas the latter requires surgery. Early diagnosis is also imperative to prevent spinal fractures or pseudarthrosis by starting anti-inflammatory treatment immediately after diagnosis.[6] To stop the inflammatory reaction, non-steroidal anti-inflammatory drugs and sulfasalazine are commonly administered following surgery.[2,4,12] Anti-tumour necrosis factor-α is avoided owing to the associated immunosuppression, which might result in SSI.[8] Langlois et al[5] reported that conventional treatment achieved consistently favourable clinical outcomes in most of their AL patients (12/14). However, Bron et al[21] reported that conservative management is less efficient at the more mobile cervical and thoracolumbar levels compared with less mobile levels. Conservative management is also unsuitable for pseudarthrosis. Minimally persistent motion owing to pseudarthrosis hinders fracture healing and union at ALs. Neither brace immobilization nor Halo jacket immobilization can eradicate this minimally persistent motion.

The main argument in the debate over surgical treatment is the necessity of anterior support reconstruction. To directly remove the lesion and facilitate bone grafting, the anterior approach reported by Fang et al[9] was once considered the best surgical method for AL. Villanueva[14] reported good clinical outcomes in patients with Cawley type III AL who underwent a double-approach surgery. Chen et al[29] also reported the effectiveness of surgical treatment with both posterior fixation and anterior fusion. However, Chang et al[10] considered that anterior fusion was unnecessary owing to the excellent reunion ability of ankylosing spondylitis. The early histological findings reported by Nikolaisen and Nossent[6] supported this finding. The authors documented reactive changes with new bone formation in AL.[6]

In 2011, our preliminary study of eight AL patients who underwent surgical treatment was published. Among the eight patients, three underwent posterior fusion only, without lesion curettage and anterior support. The other five cases underwent anterior reconstruction with bone grafting and posterior fusion.[8] All cases had excellent long-term outcomes, with no cases of pseudarthrosis, although it was considered essential to reconstruct the anterior support in AL cases with severe destruction.

Because there are no established guidelines for the surgical treatment of AL, we alternate techniques for AL patients in our institution, based on the results of our preliminary study.[8] For AL cases without neurological complications, OSF or MIS is performed, regardless of the degree of anterior lesion destruction. For obvious kyphotic AL cases, Smith-Peterson osteotomy or pedicle subtraction osteotomy was performed; kyphotic AL cases were excluded in this study.

In this study, 16 cases underwent OSF, and 14 cases underwent MIS. The groups had similar operating times and TBL, and the groups had comparably favourable clinical outcomes. Additionally, the preoperative local kyphosis angles and CBVAs were similar between the groups, with no obvious correction in either parameter. No significant differences were found in VAS and ODI scores between the MIS and OSF groups. Of note, no evidence of nonunion was observed in either group. Therefore, for AL patients of this kind, we can choose a MIS approach, which can achieve the same fusion effect as open surgery. Moreover, these results support the hypothesis that solid immobilization achieved by posterior instrumentation is the most important treatment for AL. These results also indicate the important role of instability in the development of AL, and the efficacy of MIS.

This study has several strengths. First, based on our previous report of AL surgery without lesion curettage,[8] in this retrospective study, we proposed an effective and new minimally invasive method to treat AL without bone grafting, which was quite different from the standard surgery. Second, the effectiveness of MIS in this study indicated the important role of instability in the development of AL, which further supports the aetiology of mechanical forces in AL. Third, we effectively evaluated bone union using both radiographs and CT.

This study also has several limitations. The sample size was relatively small because AL is a rare complication of ankylosing spondylitis. In addition, we did not evaluate the best surgical method for kyphotic AL requiring osteotomy correction, which is a worthy topic for future research.

For AL patients, MIS provided favourable clinical and radiological outcomes, comparable to those achieved with OSF. MIS resulted in less blood loss and shorter operating time compared with OSF. Our findings support the hypothesis that solid immobilization achieved by posterior instrumentation is the most important aspect of treatment for AL. Our results also confirmed the crucial role of instability in the development of AL.

Supplementary material

Imaging data for the open spinal fusion and minimally invasive surgery groups in addition to those from those from the main article.

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Data sharing

The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Ethical review statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of The First Affiliated Hospital of Shan Dong Medical University.

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