Anterior Spinal Fusion Using Autologous Bone Grafting via the Lateral Approach with Posterior Short-Range Instrumentation for Lumbar Pyogenic Spondylitis with Vertebral Bone Destruction Enables Early Ambulation and Prevents Spinal Deformity

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Abstract:

Introduction: Pyogenic spondylitis of the lumbar spine markedly decreases the ability to perform activities of daily living and causes severe low back pain. The challenge is to improve low back pain and activities of daily living performance earlier and prevent post-infection sequelae, and conservative treatment with antibiotics is the mainstay of treatment.

Methods: In the present study, patients who were unable to walk following lumbar pyogenic spondylitis even in the subacute phase after successful infection control, showing bone defects expanding from endplate to vertebral body in CT, were treated with posterior percutaneous short-range instrumentation and anterior autogenous bone grafting (group S, n = 10) or with conservative treatment alone (group C, n = 10). Acute cases of absolute surgical indication with paralytic symptoms and mild cases who could walk by antibiotics administration were excluded. The two groups were compared regarding the post-treatment change in C-reactive protein level, duration of bed rest, and post-infection local spinal deformities (local scoliosis angle in the coronal plane and local kyphosis angle in the sagittal plane).

Results: Compared with group C, group S took a significantly shorter time for the C-reactive protein level to return to normal and required a significantly shorter duration of bed rest. Furthermore, surgery prevented the formation of kyphosis and scoliosis, while group C developed local kyphosis.

Conclusions: The minimally invasive surgical method of posterior percutaneous short-range instrumentation and anterior autogenous bone grafting effectively enables early control of pain and maintenance of locomotive function and prevents spinal deformity in patients with lumbar pyogenic spondylitis in the subacute phase with advanced vertebral bone destruction.

Keywords:

pyogenic spondylitis, surgical treatment, lateral retroperitoneal approach, minimally invasive surgery, spinal deformity, low back pain, activities of daily living, lumbar spine

Spine Surg Relat Res 2020; 4(4): 320-327
dx.doi.org/10.22603/ssrr.2020-0049

Introduction

Lumbar pyogenic spondylitis results in severe low back pain, which necessitates bed rest and decreases the ability to perform ADL. In prolonged pyogenic spondylitis, the intervertebral disc narrows and vertebral body deformation often results in spinal deformity[1)]. Where surgery is required for those who are resistant to conservative treatment, treatment for pyogenic spondylitis basically comprises bed rest and infection control via the administration of antibiotics[2)]. Although the usefulness of surgical treatment for pyogenic spondylitis has been shown[1,3,4)], there is no clear standard for surgical indications and procedures, and few studies have evaluated the appropriateness of staging and procedures. In the present study, we evaluated after successful infection control the significance of anterior fusion using autologous

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Received: March 30, 2020, Accepted: May 1, 2020, Advance Publication: June 18, 2020

Table 1. Demographic Data of the Patients with Pyogenic Spondylitis Who Received Surgical Treatment (Group S) vs. Conservative Treatment (Group C).

	Age	Gender	Level	Related history	Blood Culture	Ope time	Blood loss	PPS
Surgical treatment (S)								
1	66	M	L2/3	unclear	Negative	110	25	1A1B skip
2	54	M	L3/4	block injection	Negative	112	40	1A1B site
3	61	F	L3/4	hari puncture	Streptococcus	98	20	1A1B skip
4	81	M	L1/2	unclear	Negative	140	50	2A2B site
5	48	F	L4/5	unclear	Negative	110	50	2A2B site
6	61	M	L4/5	T1DM, IE	Streptococcus oralis	128	50	1A1B site
7	69	F	L4/5	unclear	Negative	120	60	1A1B site
8	67	M	L2/3	CHF	Negative	150	60	1A1B site
9	82	M	L2/3	DM	Negative	100	25	2A2B site
10	74	M	L2/3	DM, HCC	Negative	110	5	1A1B site
Conservative treatment (C)								
1	84	M	L1/2	DM	Peptostreptococcus sp.			
2	73	M	L2/3	Atopic dermatitis	MSSA			
3	64	M	L2/3	HD	Negative			
4	67	F	L2/3	CTx (lung ca)	Negative			
5	66	F	L4/5	CTx (Uterine ca)	MSSA			
6	57	M	L4/5	HD	MSSA			
7	77	M	L2/3	GIST	Negative			
8	64	M	L3/4	DM	MSSA			
9	47	M	L2/3	IE	Streptococcus mitis			
10	79	F	L4/5	unclear	MRSA			

bone grafting via the lateral transpsoas approach after posterior short-range spinal stabilization in the prone position for lumbar pyogenic spondylitis with advanced vertebral bone destruction in the subacute phase.

Materials and Methods

Patients

The study population comprised 20 patients with lumbar spinal pyogenic spondylitis with low back pain and movement difficulty. In all patients, MRI showed inflammation of the upper and lower vertebral bodies and endplates, and CT showed bone defects expanding from endplates to vertebral bodies (Grade III in the literature described by Pee YH, et al.[5]). Conservative treatment was administered, which consisted of identification of the causative bacteria and antibiotic administration. The participants had prolonged low back pain and could not walk even in the subacute phase. We presented two methods (change to surgical treatment and continued conservative treatment) to patients when the infection had been controlled (normal body temperature, normal white blood cell number, and decreasing C-reactive protein [CRP] concentration were judged), and the patients chose either one. The group that underwent surgery (group S) and the group that received conservative treatment alone (group C) were compared regarding the time taken to regain the ability to walk (restoration of gait function was defined as the ability to be able to walk 10 meters or more without assistance or a walker), and the time from the initial examination to the return of the elevated CRP concentration to a normal level of less than 0.3 mg/dL. The groups were also compared regarding CT changes in local vertebral morphology (coronal and sagittal) at admission, immediately after surgery, and at more than one year after admission. Patients with chronic inflammatory diseases, acute cases of absolute surgical indication with paralytic symptoms and mild cases who could walk were excluded. The demographic data of each group are shown in Table 1.

Surgical treatment

The patient was initially placed in the prone position, and percutaneous pedicle screws were inserted to achieve stabilization from the posterior aspect in situ. The screws were inserted into one vertebra above and one vertebra below the affected vertebra. The affected vertebral body was skipped and fixed in cases where the infection could not be completely controlled by antibiotics and cases with large bone defects. The patient was then repositioned to the lateral position, and the anterior intervertebral disc and bone were scraped using a nerve monitoring device and a retractor for extreme lateral interbody fusion (XLIF) via the transpsoas approach[6], followed by autologous bone grafting (Fig. 1A). Graft bones were collected tricortically from the iliac wing on the entry side, and had the same diameter as the vertebral body and a width of approximately 15 mm (Fig. 1B). The bone graft was inserted into the space surrounded by the upper and lower sliders (Fig. 1C), and an anterior longitudinal ligament retractor or elevatrium was inserted into the disc and used as a blocker in front of the bone graft. The

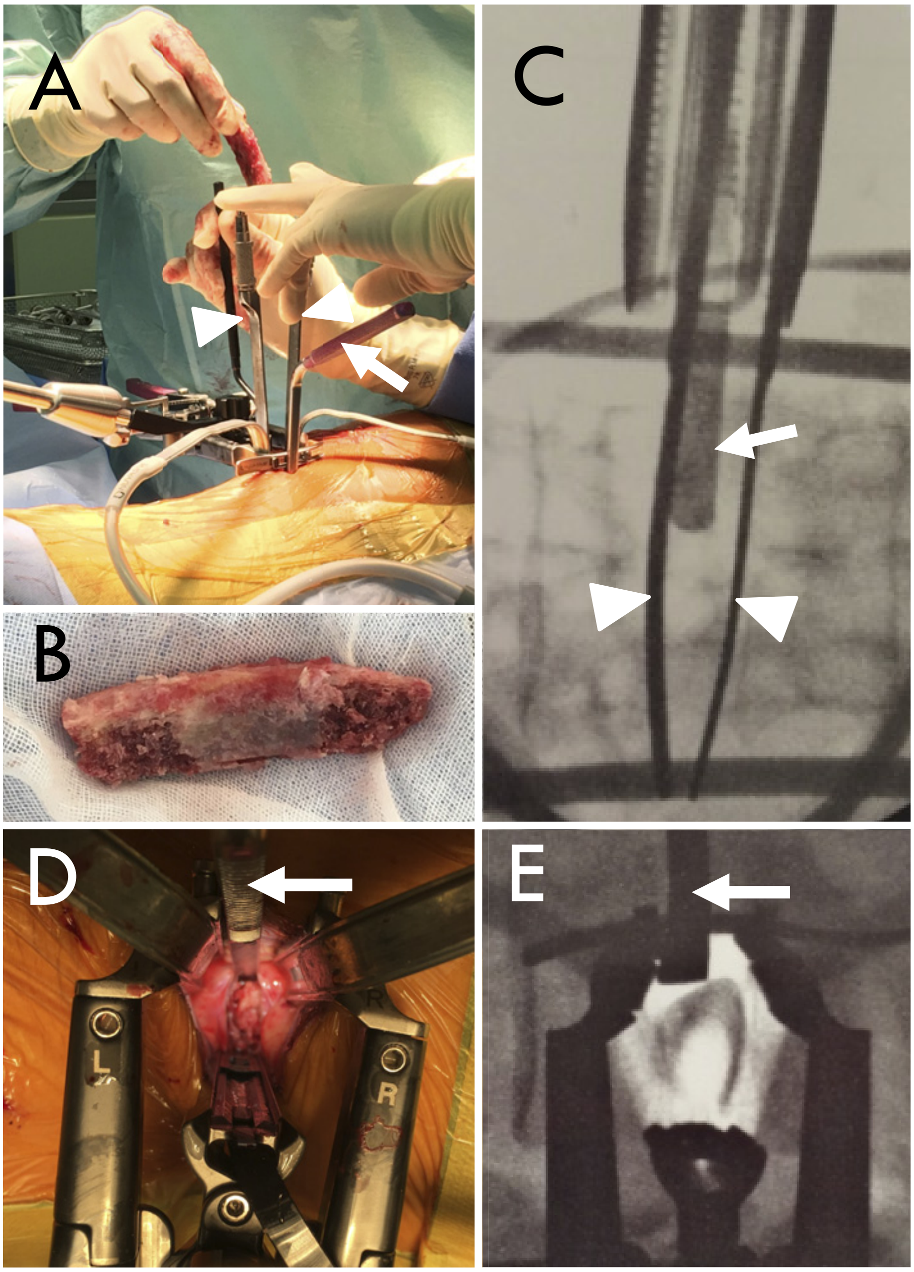

Figure 1. Laterally approached anterior fusion via a small incision.
(A) A retractor with a light source is installed, and an anterior longitudinal ligament retractor (arrow) and two sliders (arrow heads) are inserted. (B) The graft bone is collected tricortically from the iliac wing on the entry side and trimmed to fit the bone defect. (C) The bone graft is inserted between the sliders while the front view of the lumbar spine is visualized under fluoroscopy. (D) The position of the graft bone is confirmed to be behind the anterior longitudinal ligament retractor (arrow). (E) The position of the graft bone is confirmed from the lumbar spine lateral view. The graft is implanted in the space behind the anterior longitudinal ligament retractor (arrow).

anterior-posterior position of the grafted bone was confirmed by direct vision (Fig. 1D) and fluoroscopy (Fig. 1E). All cases were performed by a 20 year-experienced spine surgeon.

Conservative treatment

Conservative treatment comprised antibiotic administration, rigid corset application, and rehabilitation under the guidance of a physiotherapist.

Rehabilitation and post-treatment therapy

In each group, walking exercise was started based on each patient's tolerance of the pain. The time at which bed rest ended was defined as the timepoint at which the patient was able to walk 10 meters or more without assistance or a walker. Bone morphogenic protein-2 and teriparatide prepa-

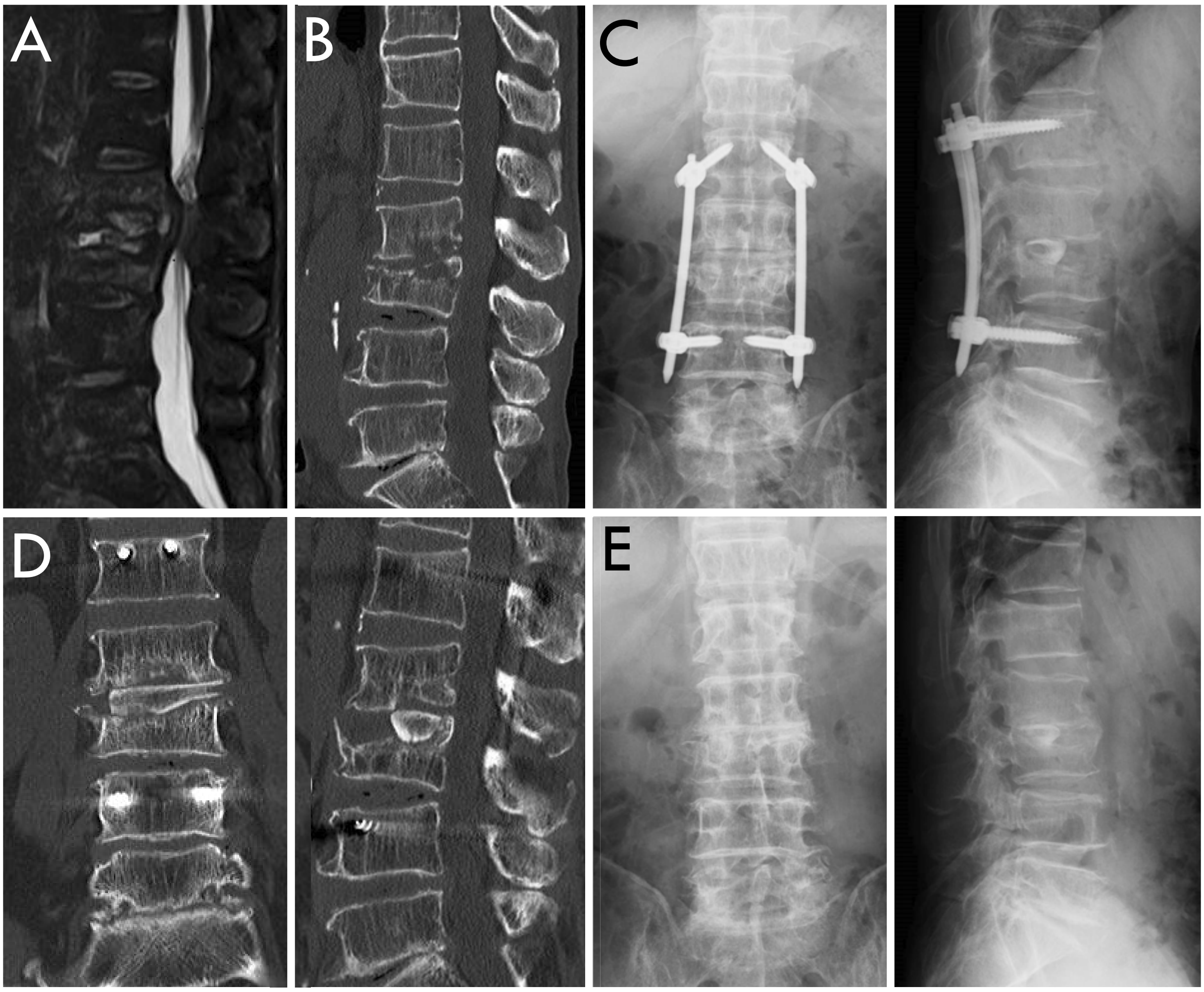

Figure 2. Images from a patient treated surgically for pyogenic spondylitis (case S-1).
Case S-1 is a 66-year-old man with a three-month history of low back pain who developed increased lower limb pain and difficulty walking several days prior to presentation.
(A) T2WI fat suppression MRI at initial examination shows inflammation extending from the L2/3 disc to the upper and lower vertebral bodies, and an abscess extending from the vertebrae to the spinal canal. (B) CT at the first examination shows bone defects in the L2/3 vertebral bodies, collapse of the L3 vertebral body, and local kyphosis. (C) Postoperative X-P and (D) CT confirm the position of the graft bone and lumbar lordosis. (E) At 6 months postoperatively, radiographs show bone fusion, and the posterior implants are removed.

rations were not used. The posterior percutaneous pedicle screws that were inserted to skip the affected vertebrae were removed after bone fusion was confirmed on imaging.

Spine morphometry

CT images were obtained at the time of admission, immediately after surgery, and when healing had been achieved. The angles between the upper and lower vertebral endplates of the affected vertebral body in the center slice of the vertebral body in the sagittal and coronal planes (local kyphosis angle and local scoliosis angle) were measured.

Statistical analysis

Mann-Whitney's U-test was used for comparisons between the two groups, and p-values of less than 0.05 were considered statistically significant.

Results

There were 10 patients in group S and 10 patients in group C. There were no significant differences between the two groups in age, sex ratio, and level of the infection (Table 1). In group S, antibiotics had been administered for more than two weeks at the time of surgery, and the detection of bacteria in the surgical lesion was all negative. The total bleeding volume during both the anterior and posterior procedures was 38.5 ± 18.7 g, and the surgery time was 117.8 ± 16.9 min (including the time taken to reposition from the prone position to the lateral position). One patient in group S incurred an iliac wing fracture that caused local pain, but was healed at two months postoperatively. One patient in group S had transient sensory impairment of the thigh. No patient developed vascular or retroperitoneal organ damage, recurrence, or wound infection. Fig. 2 shows the

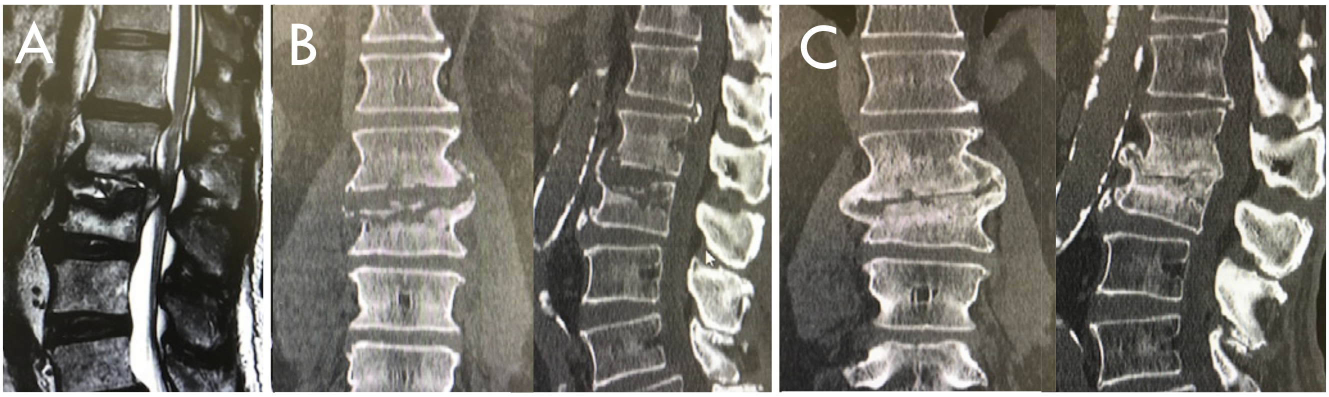

Figure 3. Images from a patient treated conservatively for pyogenic spondylitis (case C-1).
Case C-1 is an 84-year-old man with a 3-month history of low back pain. Several days before presentation, his low back pain level increased and lower limb pain developed, making walking difficult.
(A) T2WI fat suppression MRI at first consultation shows inflammation extending from the L1/2 disc to the upper and lower vertebral bodies, and an abscess extending from the intervertebral disc to the spinal canal. (B) CT at the first consultation shows bone defects in the L1 and L2 vertebral bodies and collapse of the L2 vertebral body. (C) At 1 year post-treatment, CT shows complete osteosynthesis with kyphosis.

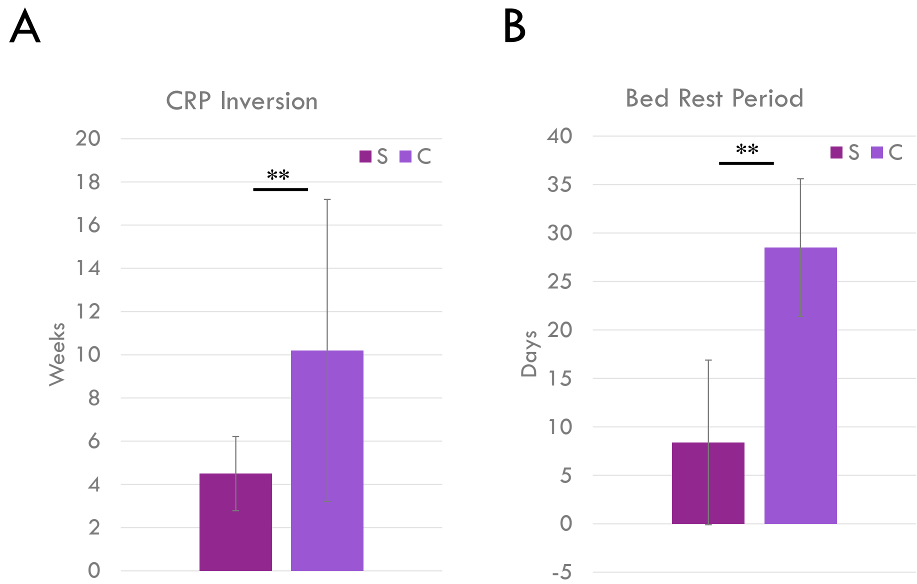

Figure 4. Comparison of the clinical course of patients with pyogenic spondylitis who received surgical treatment (S) vs. conservative treatment (C).
(A) Time required for the elevated C-reactive protein (CRP) concentration to return to a normal level (less than 0.3 mg/dL). (B) Time required for patients to regain the ability to walk independently. **p<0.01

images from a patient in group S (case S-1), while Fig. 3 shows the images from a patient in group C (case C-1).

The time taken for the elevated CRP level to decrease to less than 0.3 mg/dL was significantly shorter in group S (4.5 ± 1.7 weeks) than in group C (10.2 ± 7.0 weeks; p = 0.005; Fig. 4A). The bed rest period in group S (8.4 ± 8.5 days) was significantly shorter than that in group C (28.5 ± 7.1 days; p = 0.001; Fig. 4B). These results suggested that the infection and inflammation resolved more rapidly in group S than in group C, which enabled earlier ambulation in group S than in group C.

The local kyphosis angle at admission was 2.3 ± 9.8° in group S and 1.9 ± 8.4° in group C. In group S, the local kyphosis angle was −1.9 ± 11.3° immediately after surgery, and 1.8 ± 11.1° when healing had been achieved. In group C, the angle was 13.9 ± 7.9° at the time of healing, which was significantly higher than that at the time of hospitalization (p = 0.005; Fig. 5A). The change in local kyphosis angle during treatment was significantly smaller in group S (−0.5 ± 6.0°) than in group C (12.0 ± 7.1°; p < 0.001; Fig. 5B). Similarly, the local scoliosis angle at admission was 6.3 ± 4.6° in group S and 4.0 ± 3.8° in group C. In group S, the local scoliosis angle was 4.9 ± 2.8° immediately after surgery, and 5.4 ± 3.2° when healing had been achieved; in

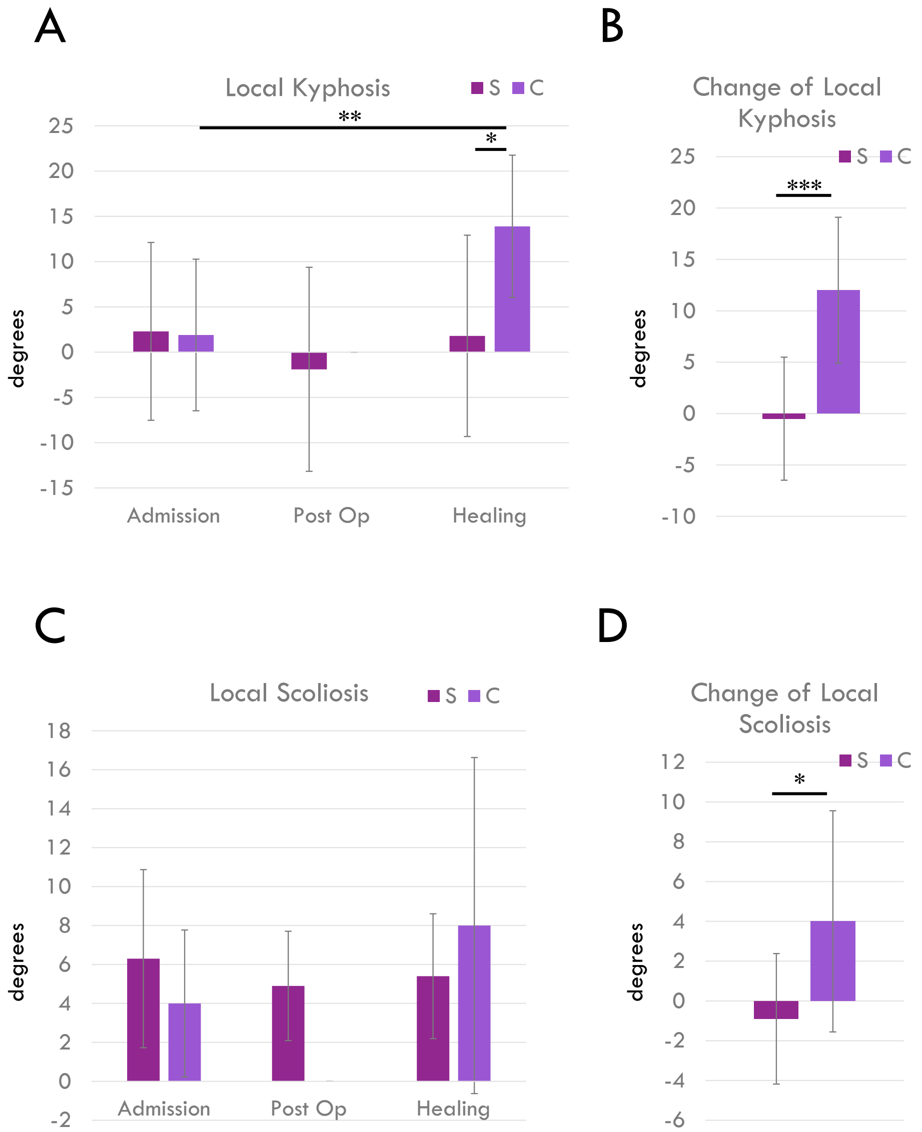

Figure 5. Comparison of the morphological changes at the infection site in patients with pyogenic spondylitis treated with surgery (S) vs. conservative treatment (C).
(A) The sagittal local kyphosis angle on CT performed at the time of admission, immediately after surgery, and when healing had been achieved. (B) Changes in the local kyphosis angle during the course of treatment. (C) The coronal local scoliosis angle on CT at the time of admission, immediately after surgery, and when healing had been achieved. (D) Changes in the local scoliosis angle during the course of treatment. *p<0.05, **p<0.01, ***p<0.001

group C, local scoliosis angle was 8.0 ± 8.6° when healing had been achieved (Fig. 5C). The change in the local scoliosis angle during treatment was significantly smaller in group S (−0.9 ± 3.3°) than in group C (4.0 ± 5.6°; p = 0.020; Fig. 5D). These results showed that group C healed with local kyphosis, while group S did not develop this deformation.

Discussion

Pyogenic spondylitis is basically controlled by antibiotics[4]. The indication of surgical treatment of pyogenic spondylitis has not yet been established because phase of infection, host condition, and causative bacteria were variable. At this facility, even if there is pain in the lower extremities or slight weakness, the presence or absence of an abscess in the spinal canal does not meet the criteria for surgery. Weakness of lower extremities below Manual Muscle Test Grade 3 and bladder and bowel dysfunction due to abscess are indicated for emergency surgery (posterior decompression and percutaneous long-range posterior fusion surgery). We often wonder how to treat patients whose infections have been controlled but who cannot move due to pain, although acute cases with uncontrollable infection also have indication of surgery. In this study, we focus on the significance of surgery; how to cure cases which can be cured without surgery even in the subacute phase after successful infection control.

It is necessary to control infection first and relieve pain resulting from instability in order to restore gait function early, with gait disorders from the pyogenic spondylitis being thought to result from inflammation and instability. As shown in the present study, conservative treatment of symptomatic lumbar pyogenic spondylitis with bone destruction requires a prolonged treatment period and results in spinal deformity. In general, surgery for pyogenic spondylitis is broadly divided into two methods: irrigation/debridement; and stabilization of the infected lesion. However, the effects and necessity of each method are controversial. Fusion surgery is recommended for patients with pyogenic spondylitis who have neurological disorders, large bone defect, or severe kyphosis[3,7,8]. Furthermore, the method of fixing the unstable infected spine with destroyed anterior support is either posterior long (two or more above and two or more below) stabilization or posterior short-range (basically one above and one below) stabilization with anterior support reconstruction. Debridement of the infected lesion and reconstruction of the anterior strut with autologous bone transplantation, as performed in the present study, resulted in the patients being able to recover their movement ability more quickly due to the rapid relief of pain, and the infection was managed completely. It is unclear whether these outcomes were caused by the effects of stabilization or bone grafting. Mohamed et al. reported that resolution of spinal infection is achieved by stabilizing the infected site with posterior fixation without debridement[9]. In recent years, percutaneous pedicle screws have been used in minimally invasive spine surgery that preserves the posterior paraspinal tissues, and have also been used to treat pyogenic spondylitis[10]. The good outcomes achieved by spine surgery are due to the promotion of bone repair and lesion stability without touching the infected lesion, as lesion instability in pyogenic spondylitis worsens the outcome. If deformation or instability remains, it should be fused with a proper alignment, and it is doubtful whether the infected part is fused or functionally moved after posterior stabilization without bone graft and removal of instrumentation. Percutaneous posterior long stabilization without bone graft sometimes needs one more removal operation for the preservation of spinal mobility. An added benefit of the anterior bone grafting was that the fixation range was shortened, suggesting enough stability obtained with clinically minimal invasion in the present study, and long fusion was avoided.

Kyphosis of the lumbar spine greatly affects low back pain[11]. In addition, kyphosis increases disability and reduces the ability to perform ADL and quality of life[12-15]. Our results and past report indicate that infected lesions with bone destruction are healed with kyphoscoliosis deformity[1], and there is a high risk of adverse effects resulting from adult spine deformity in the future. Adverse effects resulting from remaining deformity of the lumbar spine on global alignment should be considered and the surgical treatment for keeping appropriate spinal alignment would be valuable, in order to prevent deterioration of the quality of life after pyogenic spondylitis. In the present study, we performed autologous bone grafting into a lesion with a bone defect to reduce deformed healing and promote bone fusion. Similarly, Madhavan et al. reported good results without postoperative kyphosis in eight patients who underwent lateral surgery with autologous bone grafting and posterior instrumentation[16]. In the present case series, iliac bone was trimmed in the form of an intervertebral cage, and the bone graft was safely inserted into the optimal position by using sliders and an anterior longitudinal ligament retractor for XLIF. The pros and cons of implanting artificial biomaterial into the infected area have long been debated. Korovessis et al. reported satisfactory results with anterior insertion of a titanium mesh cage and posterior instrumented fusion[17], and Blizzard et al. reported the use of a cage for XLIF instead of the strut bone[18]. Pee et al. reported that image evaluation showed that the subsidence rate is lower in patients treated with cages vs. autologous bone[5], and anterior fixation of infected foci with a cage achieves equivalent clinical outcomes as fixation with autologous bone. As tricortical iliac bone extraction involves considerable pain and invasion, artificial bone grafts may need to be considered in the future.

The prognosis may vary depending on the infection severity and patient status at the time of admission. The surgical method described in the present study was minimally invasive, achieved good outcomes regarding operation time, blood loss, and early ambulation, and can be applied even in older adults and patients with poor general condition. The present study had limitations, as it was a retrospective study with a small number of cases. The present findings require confirmation in a future large-scale prospective study. The present surgical method remains unclarified regarding the maximum size of the bone defect and the minimum strength of spinal fixation. Further biomechanical research would be needed.

Conclusion

Posterior percutaneous short-range instrumentation and anterior spinal fusion using autologous bone grafting via the lateral transpsoas approach for pyogenic spondylitis is a safe and minimally invasive procedure that improves the ability to perform ADL early in the recovery period and prevents spinal deformity.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Ethical Approval: This study is retrospective and anonymous. No financial burden or physical invasion was added to patients.

Acknowledgement: We thank Kelly Zammit, BVSc, from Edanz Editing (www.edanzediting.com/ac), for editing a draft of this manuscript.

Author Contributions:

Study conception and design: HN, TO, YO, KK

Acquisition of data: HN, KM, NK, TS, TH

Analysis and interpretation of data: HN, KM, NK, TS, TH

Drafting of manuscript: HN

Critical revision: HN, TO, YO, KK

Informed Consent: Informed consent was obtained from all participants in this study.

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