



# Comparative analysis of different treatment strategies for septic spondylitis: a retrospective study of one hundred and twelve patients

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## Abstract

**Purpose** To compare the clinical efficacy and prognosis differences between conservative treatment and surgical treatment in patients with non-serious neurologically intact pyogenic spondylitis (Nsi-Nsni-PS), and to provide theoretical reference for the clinical treatment of Nsi-Nsni-PS patients.

**Methods** A retrospective analysis was conducted on 112 cases of Nsi-Nsni-PS patients treated in our hospital from June 2016 to June 2021. According to different treatment methods, they were divided into conservative treatment group (53 cases) and surgical treatment group (59 cases). The general data, laboratory tests, imaging examinations, length of hospital stay, duration of antibiotic use, VAS for pain before and after treatment, ODI, local kyphotic angle correction of diseased vertebrae, and recurrence rate were collected and analyzed in both groups. SPSS 26.0 statistical software was used for analysis. Measurement data were expressed as mean  $\pm$  standard deviation, and independent sample t-test or rank sum test was used for comparison between groups, while variance analysis was used for intra-group comparison. Count data were expressed as number (%) and compared between groups using chi-square test or Fisher's exact test. Mann-Whitney U test was used to evaluate the changes in local kyphotic angle between the two groups. A p value  $< 0.05$  was considered statistically significant.

**Results** There were no significant differences in general data and imaging characteristics between the two groups ( $P > 0.05$ ); there were no statistically significant differences in the positive culture rate of pathogens, length of hospital stay, duration of antibiotic use, treatment complications, WBC, CRP, ESR levels at admission and discharge, VAS and ODI at admission and last follow-up between the two groups ( $P > 0.05$ ). The WBC and CRP levels of patients in the conservative group at discharge were lower than those in the surgical group ( $P < 0.05$ ), and there was no significant difference in the decrease in inflammatory indicators (WBC, CRP, ESR) between the two groups ( $P > 0.05$ ). By the last follow-up, the neurological function of patients in both groups had significantly improved compared to admission ( $P < 0.05$ ), with 12 out of 15 ASIA grade D patients in the conservative group recovering to grade E, and 21 out of 25 grade D patients in the surgical group recovering to grade E, with no worsening of neurological function in either group. The differences in VAS and ODI scores at the last follow-up compared to before treatment were statistically significant in both groups ( $P < 0.05$ ), and all patients regained normal activity. Compared with before treatment, the correction degree of local kyphotic angle in the surgical group at the last follow-up was  $0.93 \pm 4.94^\circ$ , slightly higher than that in the conservative group ( $-0.83 \pm 3.37^\circ$ ), and the difference was statistically significant ( $P < 0.05$ ).

**Conclusions** During our follow-up, we found that both conservative and surgical treatments achieved satisfactory clinical outcomes in patients with Nsi-Nsni-PS. Compared to conservative treatment, surgical intervention did not demonstrate significant advantages in reducing hospitalization time and antibiotic usage duration, increasing pathogen culture positivity rate, lowering treatment complications, or controlling recurrence. However, surgical intervention showed superiority in correcting the local kyphotic angle of spinal lesions, albeit with relatively increased surgical trauma, risks, and treatment costs. At the last follow-up, the surgical group did not exhibit better long-term efficacy. Therefore, when formulating clinical treatment strategies for patients with Nsi-Nsni-PS, it may be preferable to prioritize conservative treatment, supplemented by the use of sensitive or empiric antibiotics for infection management, to improve patient prognosis.

**Keywords** Pyogenic spondylitis · Discitis · Vertebral osteomyelitis · Conservative treatment · Surgical treatment · Treatment outcome

## Abbreviations

PS	Pyogenic Spondylitis
Nsi-Nsni-PS	No spinal instability and No severe neurological impairment Pyogenic Spondylitis

## Introduction

Pyogenic spondylitis (PS) is an infectious disease affecting different parts of the spine caused by pyogenic bacteria, also known as pyogenic osteomyelitis of the vertebra. Its incidence ranges from 2.2 to 7.4 per 100,000 people [1, 2]. PS accounts for 2–7% of all osteomyelitis cases, with most primary infections originating from skin, urogenital, and respiratory tract infections, and a minority resulting from trauma or post-lumbar spine surgery infections, affecting vertebral bodies and intervertebral tissues, which may progress to systemic and neurological deterioration, leading to kyphotic deformity of the spine [3]. In recent years, the incidence of PS has been gradually increasing, possibly due to extended life expectancy and the high prevalence of chronic diseases among patients. Despite advancements in medical technology and antibiotic usage, the disability and mortality rates among PS patients have significantly decreased [4].

Currently, the majority of PS cases can be managed conservatively, with only 10–20% of patients requiring surgical intervention. Surgical indications recognized in the literature include worsening neurological symptoms, spinal instability or deformity, the presence of extensive epidural abscesses compressing nerves, persistent fever or septicaemia, and uncontrolled pain symptoms refractory to analgesics [5–8]. However, there is a lack of unified understanding regarding surgical indications and treatment principles for patients with Nsi-Nsni-PS, leading to significant debate on treatment selection. Some studies report that non-surgical treatments such as antibiotics are effective for patients without paralysis or significant spinal instability, with no significant complications during treatment [9–11], and conservative management is also indicated for minor neurological symptoms caused by lumbar-sacral epidural abscesses [12–14]. Conversely, some scholars argue that early surgery provides strong fixation, facilitates early rehabilitation training, reduces hospitalization days and antibiotic usage, and directly removes infectious lesions, corrects spinal instability and nerve compression, leading to better functional outcomes. Currently, we have observed a gradual increase in surgical interventions for Nsi-Nsni-PS patients in clinical practice, yet postoperative treatment outcomes, long-term efficacy, and there is limited literature.

Therefore, our research group aims to retrospectively collect medical records of Nsi-Nsni-PS patients, statistically analyze the differences in general data and imaging features between conservative treatment and surgical treatment

groups, analyze differences in pathogen culture positivity rate, changes in inflammatory indicators, treatment complications, length of hospital stay, duration of antibiotic usage, improvement in neurological function, and recurrence rate between different treatment modalities, observe differences in long-term clinical efficacy and prognosis between the two groups, and provide theoretical reference for clinical decision-making by healthcare professionals.

## Materials and methods

### Inclusion criteria and exclusion criteria

#### Inclusion criteria

- (1) Diagnosed with pyogenic spondylitis (PS).
- (2) American Spinal Injury Association (ASIA) Neurological Function Score: Grade D-E.
- (3) Underwent conservative treatment such as bed rest, antibiotic therapy for infection control, or

#### Surgical intervention

- (1) Pyogenic spondylitis (PS) following spinal surgery.
- (2) Concurrent with tuberculous or other spinal infections, or neoplastic diseases.
- (3) Spinal Instability Spondylodiscitis Score (SISS) > 10 [15], indicating spinal instability.
- (4) Incomplete clinical data, missing follow-up information, or lost to follow-up.

### PS diagnostic criteria and research objects

#### PS diagnostic criteria

Diagnosing pyogenic spondylitis (PS) requires comprehensive analysis of the patient's clinical symptoms along with laboratory, imaging, pathological examinations, and pathogen detection. According to relevant literature reports, the diagnosis of PS should include the following components [16–18]:

- (1) Neurological symptoms such as back pain and limb numbness or pain corresponding to the spinal lesion area.
- (2) MRI imaging characteristics showing inflammatory manifestations such as discitis, vertebral osteomyelitis, endplate destruction, and abscess formation.
- (3) Laboratory findings including C-reactive protein > 10 mg/L, erythrocyte sedimentation rate > 20 mm/h, and fever > 38 °C.
- (4) Positive blood culture for pathogens on two occasions.

- (5) Positive culture of spinal lesion tissue.
- (6) Positive pathological examination.

The presence of any two items from 1, 2, and 3 suggests a possibility of PS; the presence of any one item from 1, 2, and 3 along with item 4, or any one item from 2, 5, and 6 along with item 3, highly suspects PS; the presence of any one item from 1, 2, and 3 along with item 5, simultaneous presence of 5 and 6, or any one item from 4, 5, and 6 along with item 2 confirms the diagnosis of PS.

### Object of study

According to the inclusion criteria, 112 patients diagnosed with non-spinal instability and non-severe neurological impairment pyogenic spondylitis (Nsi-Nsni-PS) who received treatment in the orthopedic department of our hospital from June 2016 to June 2021 were selected. Our study did not require further ethics committee approval as it did not involve animal or human clinical trials and was not unethical in accordance with the ethical principles outlined in the Declaration of Helsinki.

### Research Object Grouping and treatment methods

#### Grouping of research subjects

**Conservative Group** (1) Patients who did not undergo surgical intervention within three weeks of antibiotic treatment. (2) Patients who underwent surgical intervention after three weeks or more of antibiotic treatment due to poor conservative treatment outcomes.

**Surgery Group** Patients who underwent lesion clearance surgery within three weeks of antibiotic treatment.

#### Treatment methods for research subjects

**Conservative Treatment** Comprehensive examination and tests are performed, including blood culture, puncture biopsy for bacterial culture, and pathological examination. Empirical antibiotic therapy is initiated based on the patient's clinical condition, often using a combination of third-generation cephalosporins and vancomycin. Patients are advised bed rest, nutritional support, and limited ambulation with the assistance of external fixation devices. If pathogen culture is positive, sensitive antibiotics are selected based on sensitivity testing. Blood routine, liver and kidney function, and inflammatory markers are monitored every three days. Intravenous antibiotic therapy typically lasts for four weeks

or until clinical symptoms improve, inflammatory markers significantly decrease, and imaging shows no obvious progression. If symptoms do not improve after one week of antibiotic therapy or if the decrease in inflammatory markers is less than 50% after three weeks, antibiotic adjustment is considered. Oral antibiotics are continued for two to four weeks after completion of intravenous therapy (Fig. 1). If conservative treatment is ineffective after three weeks or more, surgical intervention is performed.

**Surgical Treatment** Comprehensive examination and tests are conducted, including blood culture, along with empirical antibiotic therapy. Depending on the lesion, anterior or posterior debridement, decompression, bone graft fusion, and/or internal fixation device placement are chosen for stabilization. Tissue samples from the lesion are sent for bacterial culture and pathological examination during surgery. Antibiotics are adjusted based on the results of pathogen culture. Bed rest, nutritional support, and regular monitoring of blood routine, liver and kidney function, inflammatory markers, and drainage are recommended. After four weeks of intravenous antibiotic therapy, oral antibiotics are administered for two to four weeks. (Fig. 2).

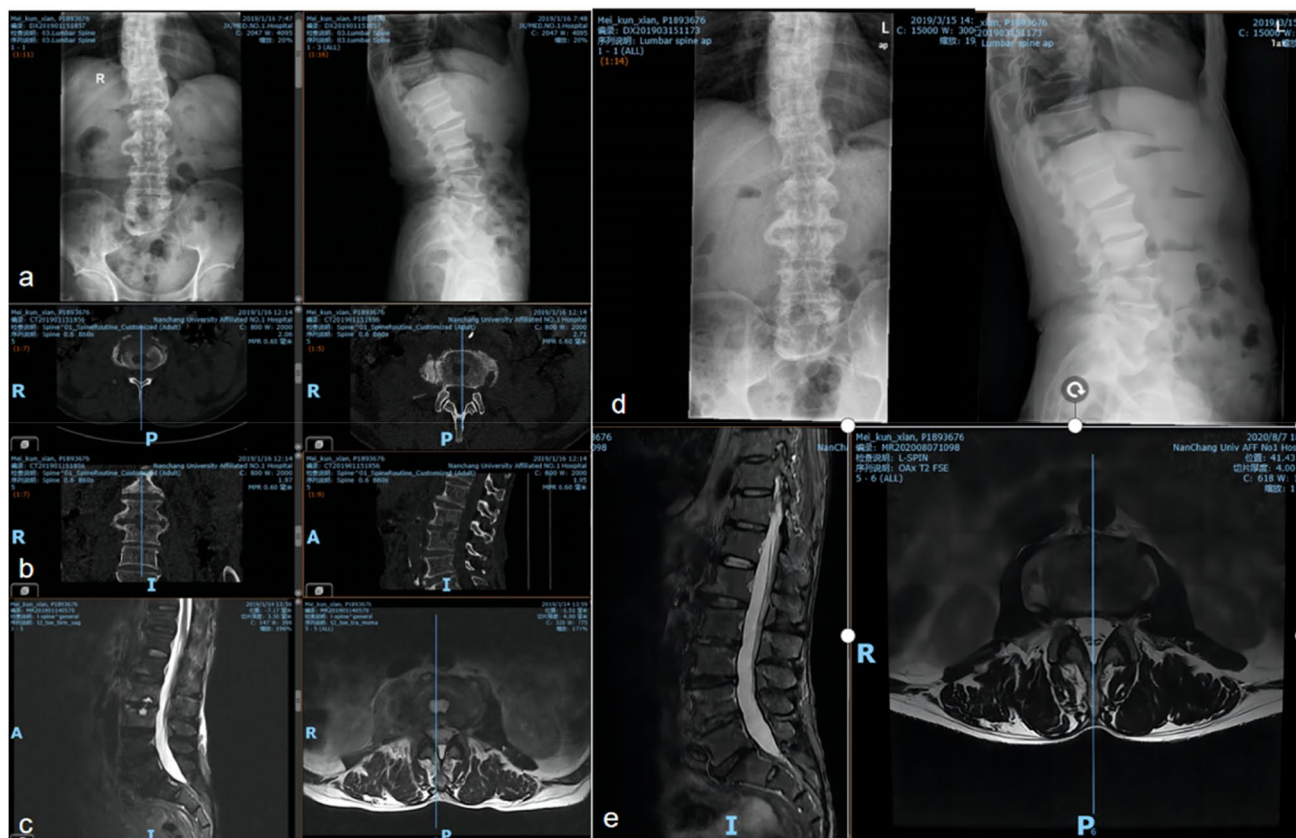
#### Clinical Data

We will collect data on patients' general information, laboratory tests, imaging examinations, length of hospital stay, duration of antibiotic use, hospitalization costs, VAS for pain before and after treatment, ODI, recurrence rate, and correction degree of local kyphotic angle of the affected vertebrae.

Measurement method of local kyphotic angle of the affected vertebrae: Based on the vertebral body involved in the patient's MRI examination, the angle between the lines drawn along the upper endplate of the affected vertebra and the lower endplate of the adjacent vertebra on lateral X-rays of the spine, or the angle between their perpendicular lines, is considered the local kyphotic angle of the affected vertebra.

Calculation method of correction degree of local kyphotic angle of the affected vertebrae: (Correction degree = measured angle of local kyphotic angle at the last follow-up - measured angle at admission).

Definition of recurrence: After the completion of treatment, the reappearance of spinal region pain or neurological symptoms that cannot be attributed to other causes, accompanied by an enlargement of the lesion area or new vertebral lesions on imaging, along with elevated CRP and ESR levels.



**Fig. 1** Imaging data of Nsi Nsni PS patients before conservative treatment (a, b, c), Imaging data of Nsi-Nsni-PS followed up for several months after standardized conservative treatment (d, e)

## Statistical methods

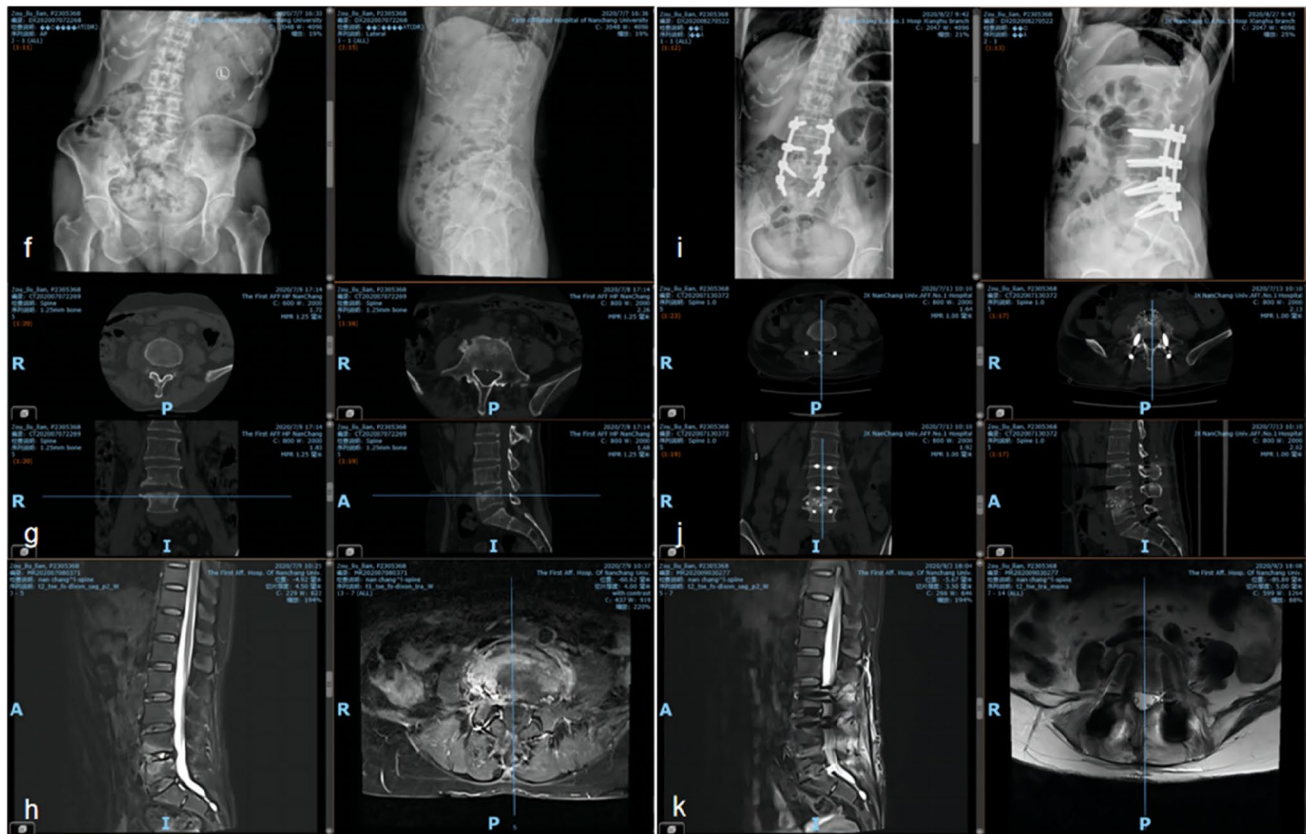
We used SPSS 26.0 statistical software package for data analysis. Continuous variables such as age, disease duration, length of hospital stay, CRP, ESR, WBC levels, VAS scores, ODI index, duration of antibiotic use, and hospitalization costs were presented as mean  $\pm$  standard deviation. Independent sample t-test or Mann-Whitney U test was used for comparison between the two groups, while analysis of variance was used for within-group comparison. Categorical variables such as gender composition, imaging characteristics, ASIA and SISS scores, and infection risk factors were presented as counts (percentages), and between-group comparisons were made using the chi-square test or Fisher's exact test. The significance level was set at two-sided 0.05. The Mann-Whitney U test was used to evaluate changes in the local kyphotic angle of the affected vertebrae between the two groups, with a significance level of  $P < 0.05$  considered statistically significant.

## Results

### General Data Comparison

A total of 112 patients were included in the study, with 68 males and 44 females, with an average age of  $60.82 \pm 11.50$  years. The average disease duration for both groups was  $33.06 \pm 21.08$  days. The average disease duration was  $30.49 \pm 19.84$  days for the conservative group and  $35.37 \pm 22.22$  days for the surgical group, with the surgical group having a slightly longer duration. Statistical analysis showed no significant differences in gender, age, or disease duration between the two groups ( $P > 0.05$ ).

All patients presented with varying degrees of lumbosacral pain upon admission, with some experiencing symptoms such as fever, limb numbness, and pain. According to the ASIA neurological function grading, there were 40 patients (35.7%) with grade D neurological function impairment in both groups before treatment, with 15 in the conservative



**Fig. 2** Preoperative imaging data of Nsi Nsni PS (f, g, h), Postoperative follow-up imaging data of Nsi Nsni PS patients (i, j, k)

group and 25 in the surgical group. According to the SISS spinal instability spondylodiscitis score, 76 patients (37 in the conservative group and 39 in the surgical group) had scores of 0–4, indicating spinal stability, while 36 patients (16 in the conservative group and 20 in the surgical group) had scores of 5–9, indicating relative spinal stability. There were more cases of patients without neurological dysfunction and spinal stability in both groups, but there were no statistically significant differences in the distribution of clinical symptoms, ASIA, and SISS scores between the two groups ( $P > 0.05$ ). Statistical analysis showed that there were no statistically significant differences in gender distribution, age, disease duration, ASIA and SISS scores, infection risk factors, and other general data between the two groups, indicating comparability of baseline characteristics ( $P > 0.05$ ).

### Imaging characteristics comparison

In both groups, infection occurred primarily in the lumbar spine in 71 cases (63.4%). Following this, infection occurred in the thoracic spine in 19 cases (17.0%), and in the lumbosacral spine in 16 cases (14.3%). Six cases (5.3%) of infection were observed in the cervical or thoracolumbar spine. A total of 99 cases involved lesions in two vertebral

bodies, with 46 cases (86.8%) in the conservative group and 53 cases (89.8%) in the surgical group. Thirteen cases involved three or more vertebral bodies, with seven cases (13.2%) in the conservative group and six cases (10.2%) in the surgical group. Single vertebral involvement was not observed in either group, and involvement of two vertebral bodies was the most common. A total of 29 cases of paraspinal abscesses occurred, with 13 cases (24.5%) in the conservative group and 16 cases (30.2%) in the surgical group (Table 1).

### Comparison of pathogenic bacterial culture results

In total, 82 patients from both groups underwent pathogenic bacterial culture of the lesions, with a positive culture rate of 35.4% (29/82). Specifically, the positive culture rate in the conservative group was 39.4% (13/33), while it was 32.7% (16/49) in the surgical group.

Within the conservative group, ten out of 59 patients underwent vertebral puncture biopsy, accounting for 18.9%. However, none of the patients in the surgical group underwent preoperative puncture biopsy for bacterial culture. Bacterial culture and pathological examination were only conducted on lesion tissues during surgery. The

**Table 1** Comparison of imaging features

Items	Conservative treatment group (n = 53)	Surgical treatment group (n = 59)	P value
<b>Spinal lesion site (cases %)</b>			0.81
Cervical spine	2(3.8)	1(1.7)	
Thoracic spine	10(18.9)	9(15.3)	
Lumbar spine	34(64.1)	37(62.7)	
Cervicothoracic spine	0(0)	0(0)	
Thoracolumbar spine	1(1.9)	2(3.4)	
Lumbosacral spine	6(11.3)	10(16.9)	
<b>Number of involved vertebrae</b>			0.62
1	0(0)	0(0)	
2	46(83.0)	53(86.4)	
≥3	7(17.0)	6(13.6)	
<b>Abscess formation (cases %)</b>			
Paravertebral abscess	13(24.5)	16(30.2)	0.76
Epidural abscess	6(11.3)	8(13.5)	0.72
Psoas abscess	5(9.4)	3(5.1)	0.47

positive rate of puncture biopsy tissue in the conservative group was 30% (3/10). There was no significant difference in the positive rates of microbial culture between the two groups ( $X^2 = 0.39$ ,  $P = 0.53 > 0.05$ ).

*Staphylococcus aureus* was the most common pathogenic microorganism (20.7%, 17/82), with 9 cases (27.3%) in the conservative group and seven cases (14.3%) in the surgical group. Other pathogenic bacteria included *Escherichia coli* (6.1%, 5/82), *Staphylococcus epidermidis* (2.4%, 2/82), *Streptococcus* (1 case), *Klebsiella pneumoniae* (2 cases), *Acinetobacter baumannii/haemolyticus* (1 case). There was no significant difference in bacterial distribution between the two groups ( $p > 0.05$ ).

### Comparison of changes in inflammatory markers

Both groups of patients showed a significant decrease in WBC, ESR, and CRP levels at discharge compared to before treatment, with statistical significance ( $P < 0.05$ , see Table 2).

The levels of WBC, ESR, and CRP in the surgical group at admission and discharge were slightly higher than those in the conservative group, but the differences were not statistically significant ( $P > 0.05$ ). However, at discharge, the surgical group had significantly higher WBC and CRP levels compared to the conservative group, with statistical significance ( $P < 0.05$ , see Table 3).

**Table 2** Comparison of treatment outcomes

Items	Conservative treatment group (n = 53)	Surgical treatment group (n = 59)	P value
Admission VAS Score	7.02 ± 0.84	7.15 ± 0.86	0.41
Final Follow-up VAS Score	1.51 ± 0.63	1.56 ± 0.70	0.70
<b>P value</b>	0.00	0.00	
Initial ODI Score	40.67 ± 4.52	41.06 ± 3.80	0.62
Final ODI Score at Last Follow-up	11.99 ± 1.63	12.54 ± 2.04	0.12
Correction of Vertebral Angle (°)	-0.83 ± 3.37	0.93 ± 4.94	0.03
Recurrence (cases %)	9(17.0)	7(11.8)	0.44

There was no statistically significant difference in the decrease in WBC, CRP, and ESR between the two groups before and after treatment ( $P > 0.05$ , see Table 4).

### Treatment complications comparison

During the treatment period, there were a total of 23 cases with complications, with a complication occurrence rate of 20.5% in both groups. Specifically, there were ten cases (18.9%) in the conservative group and 13 cases (22.0%) in the surgery group. The incidence of complications between the two groups showed no statistical difference ( $X^2 = 0.17$ ,  $P = 0.68 > 0.05$ ).

The most common complications were drug-related, mainly including leukopenia(9), abnormal liver function (5), and drug rash (1). Bedrest-related complications included urinary tract infection (2), intestinal obstruction(1), and pressure ulcers (1). There were four cases of surgery-related complications in the surgery group, include skin sinus (3) cerebrospinal fluid leakage (1).

All patients have been cured after symptomatic treatment.

### Hospital Stay Duration, Duration of Antibiotic Use, and hospitalization costs comparison

The conservative group had an average hospital stay duration of 23.55 ± 10.86 days, while the surgical group had an average hospital stay duration of 25.02 ± 10.24 days. Both groups had a hospital stay duration of less than four weeks, and there was no significant difference in hospital stay duration between the two groups. The average duration of antibiotic use in the conservative group was 53.47 ± 10.38 days, while in the surgical group it was 54.24 ± 9.97 days. Both groups had antibiotic use durations exceeding six weeks, and there was no significant difference in the duration of antibiotic use between the two groups ( $P > 0.05$ ).

**Table 3** Changes in inflammatory markers before and after treatment

Inflammatory Markers	Conservative treatment group		Surgical treatment group	
	Average Level upon Admission	Average Level upon Discharge	Average Level upon Admission	Average Level upon Discharge
WBC( $\times 10^9/L$ )	8.30 $\pm$ 2.37	5.79 $\pm$ 1.88*	8.48 $\pm$ 2.49	6.65 $\pm$ 2.12*#
CRP(mg/L)	61.38 $\pm$ 65.29	10.47 $\pm$ 7.85*	67.97 $\pm$ 53.96	14.96 $\pm$ 8.61*#
ESR(mm/h)	63.47 $\pm$ 33.06	24.72 $\pm$ 8.89*	71.86 $\pm$ 35.34	26.75 $\pm$ 9.68*

Note: \* indicates statistically significant difference compared to admission within the group ( $P < 0.05$ ); # indicates statistically significant difference between the two groups ( $P < 0.05$ )

**Table 4** Comparison of differences in inflammatory markers before and after treatment

Differences in the decrease of inflammatory markers	Conservative treatment group	Surgical treatment group	P value
WBC( $\times 10^9/L$ )	2.51 $\pm$ 2.53	1.83 $\pm$ 2.81	1.87
CRP(mg/L)	50.91 $\pm$ 64.90	52.83 $\pm$ 52.58	0.86
ESR(mm/h)	38.75 $\pm$ 32.14	45.12 $\pm$ 34.58	0.32

The treatment cost for the surgical group was  $8.34 \pm 2.39$  million RMB, while for the conservative group it was  $2.66 \pm 1.50$  million RMB. The treatment cost for the conservative group was significantly lower than that for the surgical group, showing a statistically significant difference ( $P < 0.05$ ).

**Treatment outcome comparison**

Both groups of PS patients presented with moderate to severe lower back pain upon admission, with VAS scores ranging from 5 to 8 points. At the last follow-up, both groups showed a significant decrease in VAS and ODI scores compared to before treatment, with statistical differences ( $P < 0.05$ ). The correction angle of local kyphosis after treatment in the surgical group ( $0.93 \pm 4.94^\circ$ ) was slightly higher than that in the conservative group ( $-0.83 \pm 3.37^\circ$ ), with a statistically significant difference ( $P < 0.05$ , Table 2). At the last follow-up, the neurological function of both groups of patients had significantly improved compared to admission. Among the conservative group, 12 out of 15 cases with neurological damage recovered to normal, while in the surgical group, 21 out of 25 cases recovered to normal. There were seven cases (3 in the conservative group and four in the surgical group) where neurological function did not significantly improve, and no patients experienced worsening of neurological function.

**Discussion**

This study shows that the results of pathogen culture are mainly dominated by Gram-positive cocci (21/29, 72.4%), among which Staphylococcus aureus is more common in Gram-positive cocci, and Escherichia coli is more common in Gram-negative cocci. This is consistent with the distribution of pathogenic bacteria in previous studies [17]. Research indicates that if the conservative treatment effect is not good, percutaneous biopsy should still be considered regardless of the duration of antibiotic treatment [19]. There is no significant difference in the positive rate of pathogen culture between the two groups. Among them, ten patients in the conservative group underwent puncture biopsy under the guidance of the C-arm machine during the operation, and the positive rate of culture was 30%. Relevant literature reports that the specificity of puncture biopsy reaches 99%, while the sensitivity is slightly lower, about 30-60% [20–23]. The research report of Wang et al. [24] shows that the application of antibiotics before culture will reduce the positive rate of pathogen culture. We analyzed that the reason for the low positive rate of culturing pathogenic bacteria in puncture biopsy is related to the fact that the patients have used antibiotics before taking the culture and the less puncture biopsy tissue,

and the bacterial concentration is relatively low. In the cohort study of 349 patients with sepsis by scholars such as Timothy [25], it shows that the positive rate of NGS detection is 48.6%, which is higher than that of traditional etiological detection methods, and the average detection time is 29 h. The research report of Qing et al. [26] shows that in patients who have received antimicrobial treatment, the positive rate of NGS is also higher than that of traditional bacterial culture. For PS patients, NGS detection combined with traditional pathogen detection has a higher positive rate, and sensitive antibiotics can be selected for treatment.

After undergoing anti-infective treatment, the inflammatory markers of both groups of patients decreased significantly. The reduction in ESR and CRP levels exceeded 50% at discharge for both groups, indicating the effectiveness of both conservative and surgical treatment approaches. For diagnosing PS, WBC has poor sensitivity. In our study, only 21.4% of patients had elevated WBC levels, consistent with reports in the literature where only 13–60% of PS patients had elevated WBC levels [27]. Therefore, WBC has limited utility in the diagnosis and treatment of PS. Conversely, CRP and ESR have higher sensitivity, being elevated in 70–100% of cases. However, CRP and ESR have moderate specificity and can be used to assess treatment outcomes. A decrease of 50% or more in CRP and ESR within four weeks after treatment is considered a good response to treatment [28, 29]. In this study, 91% of patients had elevated CRP and ESR levels, indicating high sensitivity and responsiveness to treatment, with inflammatory markers decreasing to near-normal levels at discharge. Literature suggests that for patients who do not have ESR below 50 mm/h and CRP below 27 mg/l after four weeks of conservative treatment, surgical intervention should be considered [30]. CRP and ESR are not specific markers of infection and can be altered by any other inflammatory condition. Regular monitoring of inflammatory markers needs to be combined with assessment of clinical symptoms to judge the effectiveness of patient treatment.

Regarding the antibiotic treatment duration of PS, there is no unified standard yet. And early surgical intervention has the advantage of strong fixation, which can reduce the occurrence of complications due to bed rest [31]. Bernard et al. [32] found in a multicenter, prospective study of 359 PS patients that there was no difference in the cure rate between using antibiotics for six weeks and 12 weeks. Some scholars also suggested using four to eight weeks of antibiotic treatment, while using antibiotics for less than four weeks might have a relatively high recurrence rate [33]. The research of Li [35] et al. showed that when anti-infection treatment was started within six weeks after the occurrence of infection, there was no significant difference in the treatment effect on bone and joint infection between the oral route and intravenous drip. The average antibiotic

use time of the two groups of Nsi-Nsni-PS was within six to eight weeks, and the treatment results showed good. The surgical group did not show an advantage in reducing inflammatory indicators and the incidence of treatment complications, reducing hospital stay and the course of antibiotic use. Conservative treatment had reliable curative effect, significantly reduced hospitalization expenses, and avoided surgical trauma and the occurrence of postoperative related complications.

In terms of imaging manifestations at the last follow-up, surgical treatment showed slightly better correction of local kyphotic angle compared to conservative treatment, exerting a certain corrective effect on spinal deformity. Fukuda et al. [10] found greater changes in local kyphotic angle before and after PS treatment in the surgical group ( $4.06 \pm 8.67^\circ$ ) compared to the conservative group ( $-3.50 \pm 4.61^\circ$ ). We attribute this difference to the relatively mild degree of bone destruction in Nsi-Nsni-PS patients, with no obvious spinal instability. Thus, even with conservative treatment, there would be no significant kyphosis, and the advantage of spinal correction in surgery was not prominently demonstrated.

In this study, the recurrence rate in the surgery group was lower than that in the conservative group; however, there was no statistically significant difference in recurrence rates between the two groups, and no significant evidence showed the advantage of surgery in controlling recurrence rates. Literature analysis of risk factors for PS recurrence shows that involvement of multiple vertebrae and formation of abscesses are risk factors for recurrence [34, 35]. In our study, 11.6% of patients showed involvement of multiple vertebrae, and more than 35% of patients had concomitant abscess formation. Therefore, we believe that more attention should be paid to Nsi-Nsni-PS patients with concomitant abscess formation during treatment and follow-up.

## Conclusion

In conclusion, both conservative and surgical treatments for Nsi-Nsni-PS patients have achieved satisfactory clinical outcomes. However, surgical intervention did not reduce hospitalization or antibiotic usage time, nor did it demonstrate advantages in improving pathogen culture positivity, reducing treatment complications, or lowering recurrence rates. While it showed some effectiveness in correcting local kyphosis of the spine, it also increased the risk of surgical trauma and incurred higher treatment costs. Therefore, when formulating clinical treatment strategies for Nsi-Nsni-PS patients, priority may be given to conservative treatment, while actively seeking microbiological evidence and opting for sensitive antibiotic therapy.



**Authors' contributions** Dong yang designed the experiments. Banglin Xie, Jing-du Wei, Biao Zhong and Jun Xiong collected the clinical data. Banglin Xie and Qiu-xiao Ai performed data analysis. Banglin Xie and Jing-du Wei wrote the paper. All authors have read and approved the final manuscript.

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**Data availability** All data generated or analysed during this study are included in this published article.

## Declarations

**Competing interests** The authors declare that they have no competing interests.

**Consent for publication** All authors approved the final manuscript and the submission to this journal.

**Informed consent** Our research was obtained from all individual participants included in the study.

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