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Clinical characteristics and outcomes by vascular access type in hemodialysis patients undergoing surgery for spondylodiscitis: a retrospective cohort study

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Abstract

Background: Spondylodiscitis is a serious complication in patients receiving hemodialysis. Vascular access may influence bloodstream infection risk, but evidence comparing access types among patients who require surgery for spondylodiscitis is limited. This study compared infectious burden, neurological involvement, treatment, and outcomes between patients using an arteriovenous fistula and those dependent on a tunneled catheter.

Methods: We retrospectively evaluated 54 hemodialysis patients who underwent surgery for spondylodiscitis at a single center between September 2019 and September 2024. Patients were grouped by vascular access documented at the index admission. Demographic, clinical, microbiological, histopathological, surgical, antimicrobial, and outcome data were reviewed. Categorical comparisons used two-sided Fisher exact tests; continuous variables were summarized descriptively when dispersion data were unavailable.

Results: Thirty-seven patients (68.5%) used a tunneled catheter and 17 (31.5%) used an arteriovenous fistula. A positive preoperative blood microbiology result was recorded in 28 catheter users and 3 fistula users (75.7% vs 17.6%; p<0.001). Intraoperative culture positivity was also more frequent in catheter users (45.9% vs 11.8%; p=0.016). Neurological involvement occurred in 35 catheter users and 3 fistula users (94.6% vs 17.6%; p<0.001), and all 12 patients presenting with fever were catheter-dependent (p=0.011). Inflammatory or discitis-related histopathological changes were found in 36 catheter users and 3 fistula users (p<0.001). Reoperation (27.0% vs 5.9%; p=0.143) and mortality during available follow-up (27.0% vs 11.8%; p=0.300) were numerically higher in catheter users but were not statistically significant. Mean intravenous antibiotic duration was 4.6 weeks in catheter users and 3.0 weeks in fistula users.

Conclusions: Among hemodialysis patients selected for surgery for spondylodiscitis, tunneled catheter dependence was associated with greater microbiological burden and more frequent neurological involvement. Differences in reoperation and mortality were descriptive and imprecise. These findings support careful surveillance for spinal infection in catheter-dependent patients and warrant confirmation in larger patient-level cohorts.

Keywords: spondylodiscitis; hemodialysis; vascular access; arteriovenous fistula; tunneled catheter; bloodstream infection; surgical outcomes

Background

Bloodstream infection remains a major cause of morbidity in patients receiving maintenance hemodialysis. A recent cohort reported bloodstream infection in 17.5% of chronic hemodialysis patients, with consequences that included prolonged hospitalization, recurrent infection, and

death [1]. Risk increases with diabetes, anemia, older age, prolonged catheter dwell time, and repeated catheter use [2].

Spondylodiscitis is a clinically important consequence of hematogenous infection. It involves the vertebral body and intervertebral disc and may extend into the epidural or paravertebral tissues. Bacteremia has been reported in approximately 53.8% of patients with pyogenic spondylodiscitis [3]. Population-based data from Germany between 2005 and 2021 estimated an incidence of 9.5 per 100000 population [4], whereas a cohort of 2557 hemodialysis patients identified spondylodiscitis in 0.4% [5].

Patients receiving hemodialysis represent a particularly vulnerable group because repeated vascular access, immune dysfunction, advanced age, and comorbidity may facilitate hematogenous seeding and complicate treatment. Spondylodiscitis in this population frequently requires prolonged intravenous antimicrobial therapy, and surgery may be necessary for neurological compromise, epidural disease, instability, deformity, failure of medical treatment, or the need for tissue diagnosis. Reported one-year mortality after spondylodiscitis ranges from 4% to 20%, and recurrence is approximately 5%; these risks may be greater in dialysis-dependent patients [6,7].

Although the lower bloodstream infection risk of arteriovenous fistula access is well recognized, few studies have examined whether vascular access type is associated with the clinical phenotype of spondylodiscitis among patients who progress to surgery. We therefore compared infectious burden, neurological involvement, histopathological findings, antimicrobial treatment, reoperation, and mortality between hemodialysis patients using an arteriovenous fistula and those dependent on a tunneled catheter.

Methods

Study design and setting

This retrospective cohort study included adult patients receiving maintenance hemodialysis who underwent surgery for spondylodiscitis in the Department of Neurosurgery at Sakarya University Faculty of Medicine between 1 September 2019 and 1 September 2024. The report was prepared in accordance with the principles of the STROBE statement for observational studies.

Ethics approval

The Sakarya University Faculty of Medicine Clinical Research Ethics Committee approved the study (approval no. E-43012747-050.04-523207-494; 10 October 2025) and waived the requirement for individual informed consent because the study used retrospectively collected, anonymized clinical data. All procedures were conducted in accordance with applicable institutional guidelines and the Declaration of Helsinki.

Patient identification and eligibility

Eligible cases were identified in the hospital information management system using diagnoses related to infective spondylopathy and chronic kidney failure. The final cohort comprised 54 patients who were receiving hemodialysis, underwent surgery for clinically and radiologically diagnosed spondylodiscitis, had adequate clinical records, and had intraoperative specimens submitted for both microbiological culture and histopathological examination.

Patients were excluded if clinical information was incomplete, pathology or culture data were unavailable, or the operation had been performed outside the study team. Patients were classified according to the vascular access documented at the index admission as arteriovenous fistula or tunneled hemodialysis catheter users.

Clinical and radiological variables

Demographic characteristics, dialysis duration, comorbid diseases, presenting symptoms, fever, neurological findings, affected spinal region, laboratory parameters, operative details, antimicrobial treatment, reoperation, discharge status, and mortality during available follow-up were retrieved from inpatient records and discharge summaries. Muscle strength was graded using the Medical Research Council scale [8]. Computed tomography and magnetic resonance imaging of the affected region were reviewed through the institutional radiology system. Magnetic resonance imaging was used to characterize disc and vertebral involvement and neural compression, while computed tomography informed assessment of osseous destruction and operative planning.

Laboratory and microbiological assessment

Preoperative C-reactive protein, erythrocyte sedimentation rate, procalcitonin, white blood cell count, and blood microbiology results were extracted from the laboratory record. Blood microbiology was treated as a composite descriptive variable because the source dataset contained both culture isolates and Wright agglutination serology. Culture isolates and serological findings are therefore reported separately in the organism distribution.
During surgery, samples of abnormal disc, bone, and soft tissue were collected under sterile conditions. Specimens intended for microbiology were submitted for aerobic culture, and separate specimens were fixed in 10% formalin for histopathological examination. Histopathological reports were categorized as showing inflammatory or discitis-related changes or fracture-predominant changes. These categories describe the sampled tissue and were not treated as independent proof or exclusion of the clinical-radiological diagnosis.

Surgical management

All procedures used a posterior approach. The operative plan was individualized according to the spinal level, neural compression, structural destruction, instability, and prior instrumentation. Tissue biopsy was obtained in every patient. Most patients underwent transpedicular screw-rod stabilization; a small number underwent isolated decompression or removal of a previously implanted system.

Outcomes

The primary comparative outcomes were positive preoperative blood microbiology, positive intraoperative culture, neurological involvement at presentation, fever at presentation, and histopathological category. Secondary outcomes were duration of intravenous antimicrobial therapy, postoperative neurological course, reoperation, discharge outcome, and all-cause mortality recorded during available follow-up.

Statistical analysis

Categorical variables are reported as number and percentage. Continuous variables are reported as mean and standard deviation or median and range, according to the available distributional information. Standard analytical principles for assessment of normality and selection of parametric or nonparametric tests were considered [9-11]. Because several variables in the final expanded dataset were available only as grouped counts, comparisons between vascular access groups were performed with two-sided Fisher exact tests, which were appropriate for the small cell frequencies. A p value below 0.05 was considered statistically significant. The mean duration of intravenous antibiotic therapy was compared descriptively because patient-level dispersion values were not available. Multivariable modeling was not performed because an

analyzable patient-level covariate matrix was unavailable. Fisher exact tests were recalculated using SciPy version 1.17.0.

Use of generative artificial intelligence

A generative artificial intelligence tool (ChatGPT, OpenAI) was used during manuscript revision for English-language editing, structural organization, and consistency checks. It was not used to generate clinical observations or alter source data. All statistical values, interpretations, and final text were reviewed and approved by the authors, who take full responsibility for the manuscript.

Results

Demographic characteristics and comorbidities

The final cohort included 54 patients receiving hemodialysis who underwent surgery for spondylodiscitis. Mean age was 65 ± 12 years; 29 patients (53.7%) were women and 25 (46.3%) were men. Hypertension and diabetes mellitus were the most frequent comorbidities. Thirty-seven patients (68.5%) used a tunneled catheter and 17 (31.5%) used an arteriovenous fistula. Demographic characteristics and comorbidities are summarized in Table 1.

Table 1 Demographic characteristics and comorbidities

Variable	n	%
Age, years, mean ± SD	65 ± 12	-
Female sex	29	53.7
Male sex	25	46.3
Hypertension	38	70.4
Diabetes mellitus	32	59.3
Cardiac disease	19	35.2
Obesity	6	11.1
Asthma or chronic airway disease	6	11.1
Previous cerebrovascular disease	6	11.1
History of malignancy	2	3.7

SD standard deviation.

Clinical and radiological findings

Lumbar involvement was the most frequently documented single-region localization, followed by thoracic and cervical involvement. The extracted regional classification was available for 52 of 54 patients; two records could not be assigned to one of the three single-region categories from the available summary data. Pain in the low back, thoracic back, or neck was present in all patients. Neurological involvement was present in 38 patients (70.4%) and was substantially more frequent among catheter users (35/37, 94.6%) than fistula users (3/17, 17.6%; $p<0.001$). Fever at presentation was documented in 12 patients (22.2%), all of whom were catheter-dependent ($p=0.011$; Figure 1). The documented single-region distribution of spondylodiscitis is summarized in Table 2.

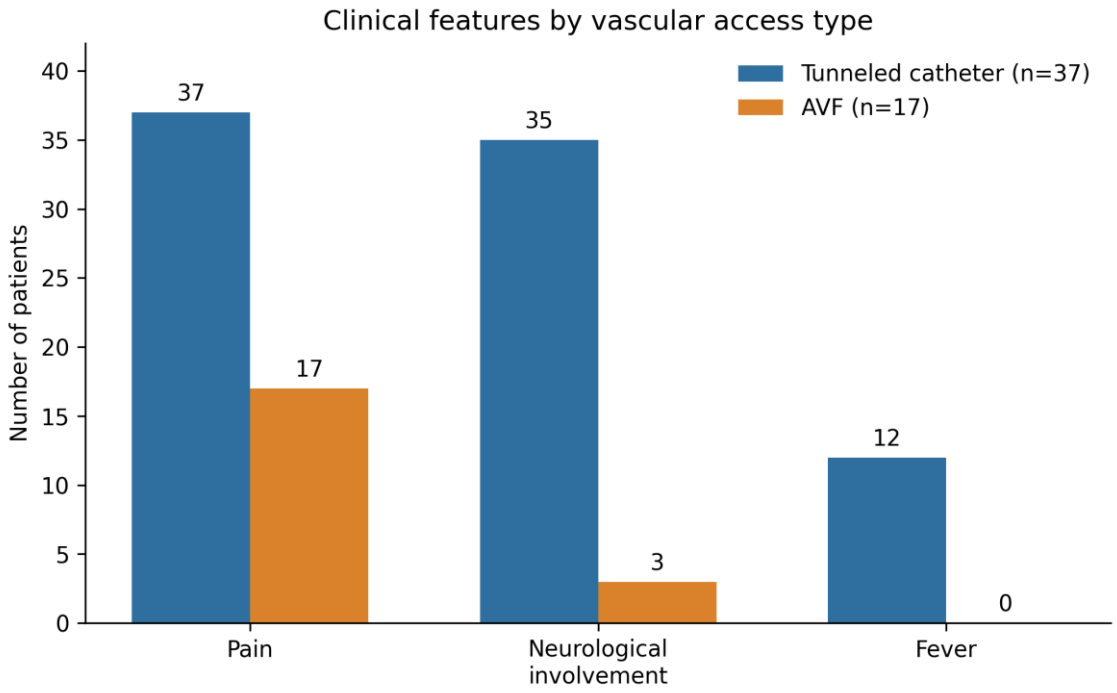


Figure 1 Clinical features by vascular access type. Counts of pain, neurological involvement, and fever at presentation in tunneled catheter and arteriovenous fistula users.

Table 2 Documented single-region distribution of spondylodiscitis

Region	n	% of total cohort
Lumbar	34	63.0
Thoracic	16	29.6
Cervical	2	3.7

Regional classification was available for 52 of 54 patients; percentages use the total cohort denominator.

Laboratory findings

C-reactive protein was elevated at admission in all 54 patients. Procalcitonin elevation was documented in 12 patients (22.2%), whereas white blood cell elevation was present in 6 (11.1%). The frequency of systemic inflammatory marker elevation therefore differed from the frequency of fever and leukocytosis. Admission laboratory abnormalities are summarized in Table 3.

Table 3 Admission laboratory abnormalities

Parameter	n	%
Elevated C-reactive protein	54	100.0
Elevated procalcitonin	12	22.2
Elevated white blood cell count	6	11.1

Surgical treatment

All 54 patients underwent operative tissue sampling. Transpedicular screw-rod stabilization was performed in 51 patients (94.4%), isolated single-level laminectomy without instrumentation in 1 patient (1.9%), and removal of a previously implanted system in 2 patients (3.7%). Representative imaging and postoperative constructs are shown in Figure 2. The surgical procedures performed in the cohort are summarized in Table 4.

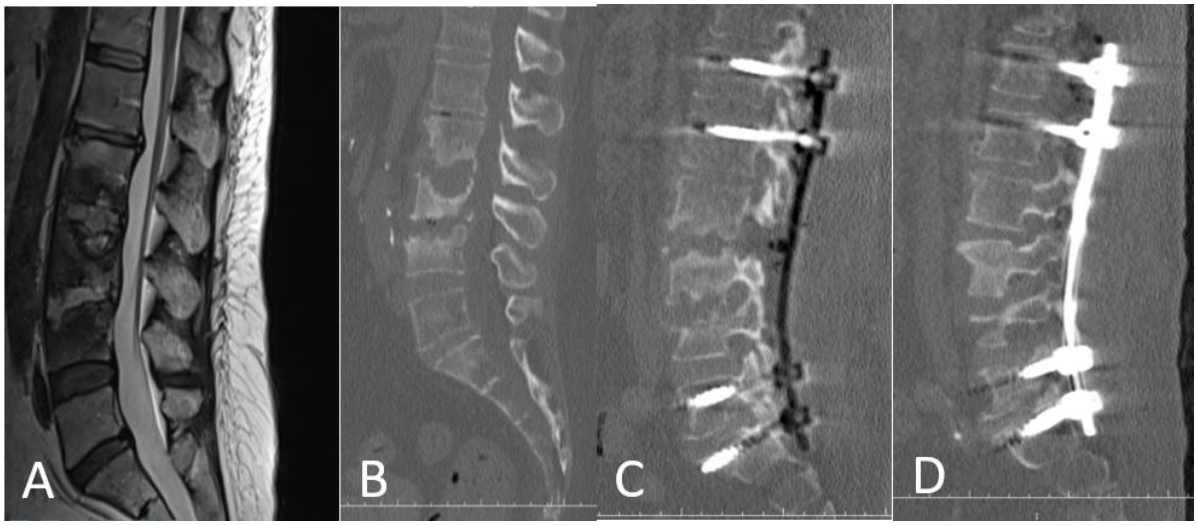


Figure 2 Imaging and surgical treatment. Representative preoperative sagittal magnetic resonance imaging and computed tomography and postoperative computed tomography showing destructive lumbar spondylodiscitis and posterior instrumentation. Panels are labeled A-D.

Table 4 Surgical procedures

Procedure	n	%
Intraoperative biopsy	54	100.0
Transpedicular screw-rod stabilization	51	94.4
Single-level laminectomy without instrumentation	1	1.9
Removal of a previously implanted system	2	3.7

Microbiological findings

Preoperative blood microbiology and intraoperative cultures were obtained or recorded for all patients. A positive preoperative blood microbiology result was documented in 31 patients, including 28 catheter users and 3 fistula users (75.7% vs 17.6%; $p<0.001$). The source data recorded 16 blood cultures growing Staphylococcus epidermidis and 12 growing methicillin-resistant Staphylococcus aureus. Three additional patients had Wright agglutination at a titer of 1:40 recorded as a serological finding; this result is not presented as a culture isolate (Figure 3).

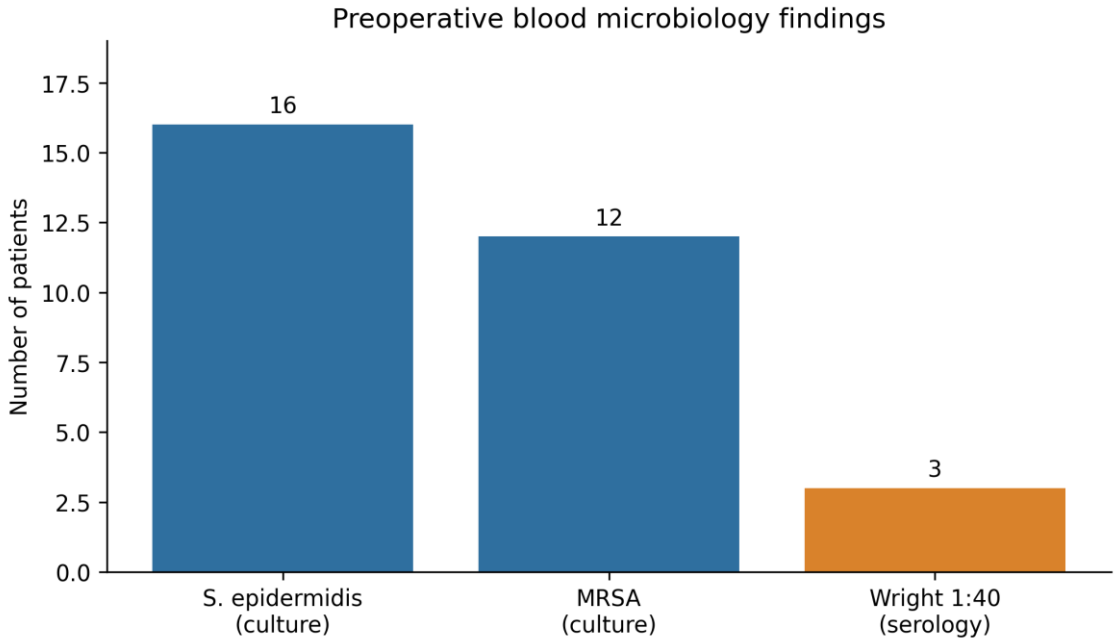


Figure 3 Preoperative blood microbiology findings. Distribution of blood culture isolates and recorded Wright agglutination serology. Wright agglutination is displayed as a serological finding and not as a culture isolate.

Intraoperative culture growth was detected in 19 patients, including 17 catheter users and 2 fistula users (45.9% vs 11.8%; p=0.016). The isolates were S. epidermidis in 10 patients, methicillin-resistant S. aureus in 3, Escherichia coli in 3, and Pseudomonas aeruginosa in 3 (Figure 4). The microbiological spectrum was predominantly staphylococcal, and positive findings were concentrated in catheter-dependent patients.

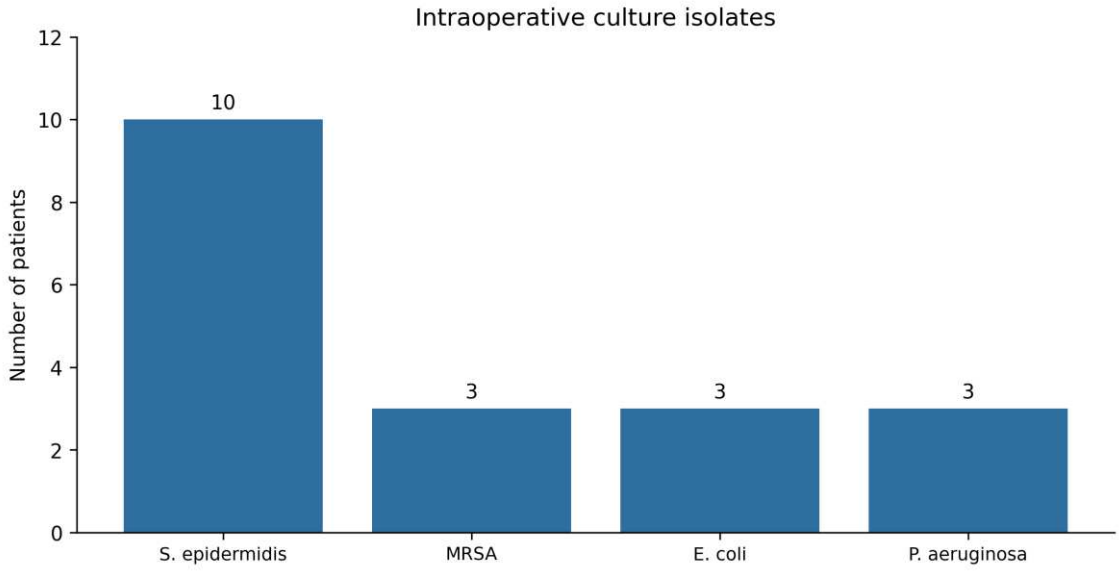


Figure 4 Intraoperative culture isolates. Distribution of organisms recovered from intraoperative tissue cultures in 19 patients.

Histopathological findings

Inflammatory or discitis-related histopathological changes were reported in 39 patients, including 36 catheter users and 3 fistula users (97.3% vs 17.6%; p<0.001). Fracture-predominant histopathological changes were reported in 15 patients, including 1 catheter user and 14 fistula users (2.7% vs 82.4%; p<0.001; Figure 5). These findings describe the dominant appearance of the submitted tissue and should be interpreted together with the clinical, radiological, microbiological, and operative diagnosis.

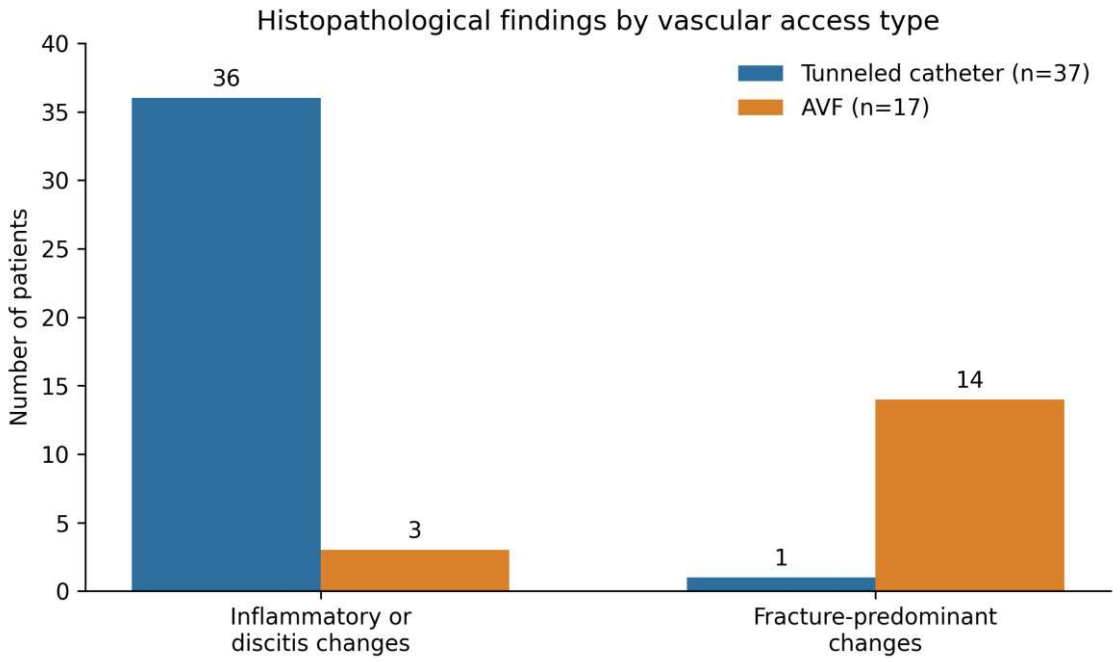


Figure 5 Histopathological findings by vascular access type. Dominant histopathological categories in tunneled catheter and arteriovenous fistula users.

Antimicrobial therapy and hospitalization

After surgery, all patients were evaluated by infectious diseases specialists and received empirical treatment followed by culture-directed antimicrobial therapy when an organism was identified. Intravenous treatment ranged from 2 to 8 weeks. Mean duration was 4.2 weeks for the overall cohort, 4.6 weeks for catheter users, and 3.0 weeks for fistula users. This difference is presented descriptively because patient-level variance was unavailable. Oral antibiotics after discharge were selected individually according to the clinical and microbiological course. Intravenous antibiotic treatment duration according to vascular access type is summarized in Table 5.

Table 5 Intravenous antibiotic treatment duration by vascular access

Group	n	Mean duration, weeks	Description
Overall cohort	54	4.2	Range 2-8 weeks
Arteriovenous fistula	17	3.0	Shorter mean duration
Tunneled catheter	37	4.6	Longer mean duration

The between-group difference was not tested because patient-level dispersion values were unavailable.

Neurological and clinical outcomes

Postoperative neurological status was unchanged in 38 patients, improved in 15, and worsened to paraplegia in 1. Reoperation was required in 11 patients: 10 catheter users and 1 fistula user. The reoperation frequency was numerically higher with catheter access, but the difference was not statistically significant (27.0% vs 5.9%; p=0.143). Forty patients were documented as discharged with clinical improvement or infection control. Discharge outcome classification was not available in the extracted summary for two patients.

Twelve patients died during available follow-up, including 10 catheter users and 2 fistula users. Mortality was numerically higher in catheter users, but the difference was not statistically significant (27.0% vs 11.8%; p=0.300). Table 6 summarizes the neurological and major clinical outcomes, and Table 7 provides the unadjusted comparison by vascular access.

Table 6 Neurological and major clinical outcomes

Outcome	n	%	Description
Neurological status unchanged	38	70.4	Most frequent postoperative course
Neurological improvement	15	27.8	Improvement after surgery and treatment
Postoperative paraplegia	1	1.9	Severe postoperative neurological deterioration
Reoperation	11	20.4	10 catheter; 1 fistula
Discharged with improvement or infection control	40	74.1	Documented favorable discharge outcome
Mortality during available follow-up	12	22.2	10 catheter; 2 fistula

Table 7 Unadjusted comparison by vascular access type

Variable	AVF n=17	Catheter n=37	Total n=54	p value
Positive preoperative blood microbiology	3 (17.6%)	28 (75.7%)	31 (57.4%)	<0.001
Positive intraoperative culture	2 (11.8%)	17 (45.9%)	19 (35.2%)	0.016
Neurological involvement	3 (17.6%)	35 (94.6%)	38 (70.4%)	<0.001
Fever at presentation	0 (0.0%)	12 (32.4%)	12 (22.2%)	0.011
Inflammatory or discitis histopathology	3 (17.6%)	36 (97.3%)	39 (72.2%)	<0.001
Fracture-predominant histopathology	14 (82.4%)	1 (2.7%)	15 (27.8%)	<0.001
Reoperation	1 (5.9%)	10 (27.0%)	11 (20.4%)	0.143
Mortality during available follow-up	2 (11.8%)	10 (27.0%)	12 (22.2%)	0.300
Mean intravenous antibiotic duration	3.0 weeks	4.6 weeks	4.2 weeks	Not tested

P values are from two-sided Fisher exact tests. Antibiotic duration was descriptive because dispersion values were unavailable. AVF arteriovenous fistula.

Discussion

The principal finding of this study was that tunneled catheter dependence was associated with a substantially greater infectious and neurological burden among hemodialysis patients selected for surgery for spondylodiscitis. Catheter users had more positive preoperative blood microbiology results, more positive intraoperative cultures, more fever, and markedly more neurological

involvement. Reoperation and mortality were numerically higher in catheter users, but the confidence provided by this cohort was insufficient to establish statistically significant differences in these outcomes.

Data focused specifically on surgically treated spondylodiscitis in hemodialysis patients remain limited. Yağdıran et al. reported chronic kidney disease in 9% of patients with spondylodiscitis, whereas Lenz et al. reported a rate of 14% [12,13]. In a 2024 tertiary-center report from Argentina, Baroni et al. described hemodialysis in 36% of spondylodiscitis patients admitted under nephrology care [14]. The present cohort addresses a narrower clinical question by evaluating only dialysis-dependent patients who reached operative treatment and comparing their presentation according to vascular access.

Mean age was 65 ± 12 years, consistent with the concentration of pyogenic spinal infection in older and medically vulnerable populations [15,16]. Hypertension, diabetes mellitus, and cardiac disease were common. These conditions may impair host defense and wound healing, complicate antimicrobial treatment, and contribute to recurrence or death [17,18]. Because group-specific comorbidity data were not available for adjustment, part of the observed association between catheter dependence and disease severity may reflect underlying differences in patient condition.

Thirty-seven patients used a tunneled catheter and 17 used an arteriovenous fistula. Catheter access provides a route for colonization and bloodstream infection, including infection with S. aureus, methicillin-resistant strains, and coagulase-negative staphylococci [19,20]. Kazakova et al. found a lower bloodstream infection risk with fistula access than with catheter access in older incident hemodialysis patients [21]. Our findings are directionally consistent: positive preoperative blood microbiology occurred in 75.7% of catheter users and 17.6% of fistula users, while intraoperative culture positivity occurred in 45.9% and 11.8%, respectively.

Pain was universal, consistent with previous descriptions of spondylodiscitis [22]. Neurological involvement was identified in 38 patients and was strongly concentrated among catheter users. This frequency approaches the upper range of neurosurgical series [23,24] and may indicate that catheter-dependent patients reach surgical assessment with more advanced infection. It may also reflect delayed diagnosis, differences in comorbidity, referral patterns, or other unmeasured factors. The retrospective design cannot distinguish among these explanations.

C-reactive protein was elevated in every patient, whereas fever and leukocytosis were much less frequent. This pattern supports the clinical value of inflammatory markers when classical systemic signs are absent [25,26]. All febrile patients were catheter-dependent, which is consistent with a greater systemic infectious burden in that group, although fever alone does not identify the source of infection.

Magnetic resonance imaging remains the primary modality for identifying disc, vertebral, epidural, and neural involvement, while computed tomography is useful for evaluating osseous destruction and planning stabilization [27,28]. Lumbar disease was the most common documented localization, followed by thoracic and cervical disease, in keeping with epidemiological reviews [29]. Regional classification was unavailable for two patients in the extracted summary, and this missingness should be considered when interpreting the anatomical distribution.

The microbiological pattern was predominantly staphylococcal. S. epidermidis and methicillin-resistant S. aureus accounted for most blood culture isolates, while gram-negative organisms were less frequent in intraoperative cultures. Gouliouris et al. similarly identified S. aureus as the leading pathogen in pyogenic spondylodiscitis, followed by coagulase-negative staphylococci and other organisms [30]. Wright agglutination at 1:40 was recorded in three patients in the

source data; because this was a serological result rather than a culture isolate, it was separated from the culture distribution in the revised presentation.

Histopathological findings differed sharply between access groups. Inflammatory or discitis-related changes were reported in 36 of 37 catheter users, whereas fracture-predominant changes were reported in 14 of 17 fistula users. Histopathology in spinal infection may vary with sampling site, prior antibiotic exposure, chronicity, and the relative contribution of infection and structural failure. The histopathological category should therefore be interpreted as the dominant appearance of sampled tissue rather than as a stand-alone diagnostic classification. Surgical sampling remains important because microbiological and pathological evaluation can complement imaging and blood cultures [31].

Instrumentation was used in 51 of 54 patients, indicating substantial structural destruction or instability at referral. Contemporary studies support posterior fixation, including screw placement in selected infected vertebrae, when stabilization is required [32]. Neurological improvement occurred in 15 patients, whereas 1 developed postoperative paraplegia. Neurological outcome after decompression for spinal infection depends on the severity and duration of preoperative compromise. More broadly, large spine surgery datasets demonstrate that perioperative neurological and medical morbidity remains clinically important, although estimates derived from degenerative lumbar stenosis should not be directly extrapolated to spinal infection [33].

Antimicrobial treatment was selected with infectious diseases consultation. Broad empirical coverage with anti-staphylococcal activity is commonly recommended until organism-specific treatment can be established [34,35]. Mean intravenous treatment duration was 4.2 weeks overall

and was longer in catheter users. Because variance and patient-level treatment data were unavailable, this difference should be considered descriptive rather than inferential.

Repeat surgery was required in 11 patients, 10 of whom were catheter-dependent. Wound complications and persistent infection contribute to morbidity after spine procedures [36], but the difference in reoperation between access groups did not reach statistical significance. Similarly, mortality was 27.0% among catheter users and 11.8% among fistula users, but this difference was not statistically significant. Lu et al. reported mortality of 16.7% among hemodialysis patients with spondylodiscitis [37]. The overall mortality of 22.2% in our cohort illustrates the vulnerability of patients who progress to surgical treatment, but the present data do not establish vascular access as an independent predictor of death.

This study has several limitations. It was retrospective, single-center, and restricted to surgically treated patients, which limits generalizability to patients managed nonoperatively. Vascular access was not assigned, and catheter dependence may represent poorer baseline health or limited fistula eligibility; confounding by indication is therefore likely. Several variables were available only as group-level summaries, preventing multivariable adjustment and inferential analysis of antibiotic duration. Follow-up duration and cause-specific mortality were not uniformly available. The preoperative blood microbiology variable combined culture and recorded serology, although these components were separated in the organism description. Regional and discharge classifications were incomplete for two patients. Despite these limitations, the consistent unadjusted differences in preoperative blood microbiology, intraoperative cultures, fever, neurological involvement, and histopathology identify catheter-dependent patients as a clinically important high-risk subgroup for further study.

Conclusions

In this single-center surgical cohort, tunneled catheter dependence was associated with more frequent positive blood microbiology and intraoperative cultures, fever, neurological involvement, and inflammatory or discitis-related histopathological changes. Reoperation and mortality were numerically higher among catheter users, but these differences were not statistically significant. The findings support heightened clinical vigilance for spinal infection in catheter-dependent hemodialysis patients and provide a basis for larger multicenter studies using patient-level adjustment. They do not establish that vascular access type independently caused the observed outcomes.

List of abbreviations

AVF: arteriovenous fistula; CRP: C-reactive protein; CT: computed tomography; ESR: erythrocyte sedimentation rate; IV: intravenous; MRC: Medical Research Council; MRI: magnetic resonance imaging; MRSA: methicillin-resistant Staphylococcus aureus; PCT: procalcitonin; SD: standard deviation; WBC: white blood cell count.

Declarations

Ethics approval and consent to participate

The Sakarya University Faculty of Medicine Clinical Research Ethics Committee approved the study (approval no. E-43012747-050.04-523207-494; 10 October 2025). The committee waived the requirement for individual informed consent because the study was retrospective and used anonymized data.

Consent for publication

Not applicable. The manuscript contains no identifiable personal information, and the radiological images are fully anonymized.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional approval and protection of participant confidentiality.

Competing interests

The authors declare that they have no competing interests.

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Authors contributions

MÖB and MK conceived the study. MÖB, SAD, and BA collected and curated the clinical data. MÖB performed the statistical analysis and drafted the manuscript. MK and TK supervised the study and critically revised the manuscript. All authors interpreted the results, read and approved the final manuscript, and accept responsibility for the work.

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