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Outcome of Re-operation in Management of Deeply Seated Spine Infection Following Index Spinal Surgeries

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ABSTRACT

Background: After prior spine surgeries, deep-seated infections pose serious clinical problems and frequently call for repeat surgical procedures. Whether, decompression by itself or in conjunction with instrumented fusion is the best surgical strategy is still up for dispute.

Aim: This study aimed to evaluate clinical and radiological outcomes of redo surgical interventions in patients with deep-seated spine infections, comparing decompression alone versus decompression with instrumented fusion.

Patients and methods: A single-center retrospective cohort study that included 21 patients was conducted at the Neurosurgery Department, Faculty of Medicine, Zagazig University. Patients were divided into two groups: Fusion-assisted decompression and decompression alone. Functional outcomes (Barthel Index), complication rates, and microbiological profiles were analyzed.

Results: The fusion group had significantly longer operation durations and higher intraoperative blood loss. Pain showed remarkable improvement in both groups, with the fusion group achieving significantly better results for back and leg pain. Functional outcomes, measured by the Barthel Index, were superior in fusion group with 36.4% achieving independence compared to none in the decompression-alone group. The recovery rate was significantly higher in fusion group compared to decompression-alone group. Staphylococcus aureus and Escherichia coli were the predominant organisms, with a higher rate of no growth in the fusion group versus the decompression-alone group.

Conclusion: Adding instrumented fusion to decompression in redo surgeries for deep-seated spine infections resulted in better pain relief, superior functional outcomes, and higher recovery rates compared to decompression alone. Despite longer operative times and increased blood loss, the overall clinical benefits support the inclusion of fusion in appropriate cases.

Keywords: Deep-seated spine infections, Redo spine surgery, Decompression, Instrumented fusion, Functional outcomes, Recovery rate, Barthel index, VAS.

INTRODUCTION

Spondylodiscitis, an uncommon infection of the intervertebral disc with osteomyelitis of the surrounding vertebral body endplates, makes for 0.15–5% of all cases of osteomyelitis [(1)]. Managing pyogenic spondylodiscitis is typically challenging. There have been reports of mortality rates ranging from 2 to 20%. A low positive rate of the pathogenic organism is one of the causes of therapeutic challenges [(2, 3)].

Three to ten percent of patients have cervical spine involvement, while fifty percent of patients have lumbar and thirty-five percent have thoracic involvement [(4)]. The patient frequently underestimates the symptoms of spondylodiscitis, which are typically nonspecific and have a gradual onset. Spinal discomfort is the most prevalent sign found during examination, and the most frequent presenting complaint is neck or back pain [(5)].

Following spine surgery, the third most frequent complication is surgical site infection (SSI). The range of SSI incidence is 0.2% to 16.1%. It results in poor outcomes, more expenses, and readmissions to the hospital [(6)]. Usually, patients arrive with growing spinal deformity, neurological deficiency, fever, or excruciating pain. In the past, bed rest, immobilization, external orthoses, and antibiotics were commonly used to treat patients with spinal infections [(7)].

Spinal infections have three different etiologies: Parasitic, granulomatous (tuberculous, brucella, and fungal), and pyogenic. The most common infection is pyrogenic, and the most common pathogen is Staphylococcus aureus, which mostly infects the spine via the hematogenous arterial pathway from a distant location. Spinal infections can be fatal and are serious. Prompt management and early diagnosis are essential. There is agreement on the diagnosis. MRI has emerged as the preferred imaging technique, and a mix of clinical, analytical, microbiological, and historical data are crucial. In contrast to diagnosis, there is still much discussion over therapy options. Spondylodiscitis can be effectively treated conservatively if it is identified early and there are no complications [(8)]. Depending on a number of variables, spondylodiscitis can be treated with anything from conservative medicinal care to surgical decompression with or without instrumented fusion. According to **Dietz *et al.*** [(9)]**,** conservative medical intervention usually entails external bracing for pain management, proper antibiotic treatment, and the isolation of an organism by culture or percutaneous biopsy. Surgical treatment options should be explored for individuals with severe compressive spinal epidural abscess (SEA), illness recalcitrant to maximum medicinal treatments, or rapidly developing neurological impairments [(10)]. Typically, this includes

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decompression and drainage of any associated SEA, debridement of sick tissue, and antibiotic irrigation, with or without stabilization [9].

PATIENTS AND METHODS

This single-center retrospective cohort study was conducted at the Neurosurgery Department of the Faculty of Medicine at Zagazig University on patients who had a spinal infection as their primary diagnosis and a decompression treatment (Index surgery) performed concurrently. Patients were divided into decompression without fusion and decompression with fusion.

Inclusion criteria: Cases with primary diagnosis of spinal infection and decompression (index surgery) was performed concurrently.

Exclusion criteria: Patients reacted favorably to medical care, patients who are not surgically fit, more than two distant levels were seen in the patients, individuals without a history of prior spine operations or procedures who developed do novo spondylodiscitis, or SEA.

Each patient was subjected to full history taking including age, sex, the infection's origin, comorbidities, symptoms upon presentation, duration of stay, 30-day readmission with a focus on any past medical history, drugs, surgeries, or invasive spinal procedures, as well as any history of tuberculosis or contact with animals. Additionally, a general clinical examination was conducted to look for primary infections and systemic diseases that could have affected the surgery, and a neurological evaluation was performed. CBC, blood grouping, PT, PTT, INR, liver and renal function, blood glucose level, CRP (the level of CRP was utilized as a serum marker throughout follow-up), ESR, urine culture, blood culture, WBC count, and sputum culture were measured. The following neuroimaging investigations were carried out: Plain X-rays, CT and MRI (with gadolinium contrast) was the gold standard for diagnosis.

Surgical procedures:

- Patients were managed using a variety of instrumental approaches and procedures based on their pathology, such as:

a. Anterior corpectomy and reconstruction using either a corpectomy cage or a titanium mesh cage and plate.
b. Posterior decompression and fixation of transpedicular screws.
c. A single-stage hybrid anterior-posterior method.
d. The posterior transpedicular screws were used to fix the lateral extra cavitary approach.
e. Posterior instrumentation and TLIF.

- Gram stain, Ziehl-Neelsen, and a specific stain for fungi were used to stain the biopsy material before it was sent for aerobic, anaerobic, fungal, and mycobacterial cultures.
- Postoperative empirical antibiotics were administered and then adjusted based on the outcomes of the cultures.
- A review of imaging studies, operational notes, and other healthcare records were conducted.
- Reoperation rate, complication rate, and clinical results were the main outcomes that were measured.

Follow up and outcome: The patient was monitored every month after surgery using the Barthel Index to measure clinical outcomes related to daily living activities and the Visual Analogue Scale (VAS) to gauge the intensity of leg and back pain. These data were compared to the preoperative state. Laboratory indicators (WBC count, CRP, and ESR) and radiographic follow-up including X-rays within three days after surgery, were also part of the follow-up. CT was performed in cases that required further examination, and MRI was performed if there was a new impairment or complication.

Ethical approval:

The study was approved by the Ethics Board of Zagazig University and an informed written consent was taken from each participant or their parents in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Statistical analyses and data presentation were carried out according to the kind of data collected for every parameter. The Student's t-test, Mann-Whitney test and Chi-square test were employed. A p-value ≤ 0.05 was considered statistically significant at the 95% confidence interval.

RESULTS

Regarding demographic information, there was no significant difference between the two groups (Table 1).

Table (1): Demographic data in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Age (years)	Mean ± SD	67.80 ± 3.29	68.27 ± 4.27	0.781	NS
	Median (IQR)	67.50 (65.50-68.75)	67.00 (65.50-71.00)		
Gender	Male	5 (50.0%)	6 (54.5%)	1.000	NS
	Female	5 (50.0%)	5 (45.5%)		

SD: Standard Deviation, **IQR:** Interquartile Range, **NS:** Non-Significant.

There was no significant difference between both groups regarding preoperative laboratory investigations (Table 2).

Table (2): Preoperative laboratory investigations in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
WBC (x10^3/L)	Mean ± SD	14.00 ± 2.75	14.36 ± 2.99	0.782	NS
Hemoglobin (g/dL)	Mean ± SD	11.47 ± 1.17	11.06 ± 1.32	0.466	NS
Random Blood Sugar (mg/dL)	Mean ± SD	123.90 ± 13.03	131.00 ± 11.04	0.192	NS
ALT (U/L)	Mean ± SD	41.20 ± 7.61	48.18 ± 6.01	0.353	NS
AST (U/L)	Mean ± SD	44.60 ± 7.99	34.82 ± 3.73	0.175	NS
Creatinine (mg/dL)	Mean ± SD	0.97 ± 0.20	0.99 ± 0.20	0.919	NS
PT	Mean ± SD	13.60 ± 0.58	13.53 ± 0.64	0.774	NS
PTT	Mean ± SD	27.88 ± 4.22	29.04 ± 4.03	0.529	NS
	Median (IQR)	27.42 (24.90-31.15)	29.50 (27.26-32.02)		
INR	Mean ± SD	1.05 ± 0.09	0.96 ± 0.13	0.149	NS
	Median (IQR)	1.08 (1.03-1.10)	0.91 (0.86-1.06)		
Bacterial Culture Results	Escherichia coli	4 (40.0%)	1 (9.1%)	0.299	NS
	Staphylococcus aureus	4 (40.0%)	5 (45.5%)		
	No growth	1 (10.0%)	4 (36.4%)		
	Pseudomonas aeruginosa	1 (10.0%)	1 (9.1%)		

SD: Standard deviation **NS:** Non-Significant, **IQR:** Interquartile Range.

According to intraoperative data, in terms of **duration of operation (minutes)**, the mean was 85.56 ± 10.92 in the decompression alone group and 120.11 ± 25.05 in the decompression with fusion group, showing a highly significant difference (p=0.001) favoring a longer operative time in the fusion group. Regarding **intraoperative blood loss (ml)**, the mean was 316.00 ± 115.01 in the decompression alone group and 517.27 ± 244.58 in the decompression with fusion group, indicating a significantly higher blood loss in the fusion group (p=0.015) (Table 3).

Table (3): Intraoperative data in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Duration of Operation (minutes)	Mean ± SD	85.56 ± 10.92	120.11 ± 25.05	0.001	HS
	Median (IQR)	83.65 (79.08-92.39)	123.89 (104.82-141.29)		
Intraoperative Blood Loss (ml)	Mean ± SD	316.00 ± 115.01	517.27 ± 244.58	0.015	S
	Median (IQR)	305.00 (202.50-417.50)	470.00 (380.00-535.00)		

SD: Standard Deviation, **IQR:** Interquartile Range, **HS:** Highly Significant, **S:** Significant.

There was no significant difference between both groups regarding inflammatory markers (Table 4).

Table (4): Inflammatory Markers in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Pre-operative CRP	Mean ± SD	37.20 ± 17.39	42.00 ± 13.94	0.492	NS
	Median (IQR)	33.00 (24.00-52.50)	42.00 (39.00-51.00)		
Post-operative CRP	Mean ± SD	12.80 ± 18.42	4.09 ± 5.50	0.803	NS
	Median (IQR)	2.50 (1.25-23.50)	3.00 (1.50-4.00)		
Pre-operative ESR	Mean ± SD	41.00 ± 15.24	46.36 ± 16.29	0.447	NS
	Median (IQR)	35.00 (30.00-57.50)	40.00 (40.00-60.00)		
Post- operative ESR	Mean ± SD	27.80 ± 16.21	20.36 ± 4.82	0.168	NS
	Median (IQR)	22.00 (20.00-28.00)	19.00 (16.50-22.00)		

SD: Standard Deviation, **IQR:** Interquartile Range, **NS:** Non-Significant.

According to **VAS**, in terms of **pre-op back pain**, the mean was 4.88 ± 0.98 in the decompression alone group and 4.18 ± 0.87 in the decompression with fusion group, with no significant difference (p=0.100). Regarding **post-op back pain**, the mean was 1.93 ± 0.86 in the decompression alone group and 0.80 ± 0.73 in the decompression with fusion group with a highly significant reduction in pain favoring the fusion group (p=0.004). In terms of **pre-op leg pain**, the mean was 6.59 ± 0.66 in the decompression alone group and 6.12 ± 0.58 in the decompression with fusion group, with no significant difference (p=0.100). Regarding **post-op leg pain**, the mean was 4.62 ± 0.57 in the decompression alone group and 3.87 ± 0.49 in the decompression with fusion group with a highly significant improvement in the fusion group (p=0.004) (Table 5).

Table (5): Pain Visual Analogue Scale (VAS) in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Pre-operative Back Pain (VAS)	Mean ± SD	4.88 ± 0.98	4.18 ± 0.87	0.100	NS
	Median (IQR)	5.20 (4.43-5.60)	4.00 (3.60-4.55)		
Post- operative Back Pain (VAS)	Mean ± SD	1.93 ± 0.86	0.80 ± 0.73	0.004	HS
	Median (IQR)	1.87 (1.23-2.52)	0.82 (0.04-1.19)		
Pre- operative Leg Pain (VAS)	Mean ± SD	6.59 ± 0.66	6.12 ± 0.58	0.100	NS
	Median (IQR)	6.80 (6.28-7.07)	6.00 (5.73-6.37)		
Post- operative Leg Pain (VAS)	Mean ± SD	4.62 ± 0.57	3.87 ± 0.49	0.004	HS
	Median (IQR)	4.58 (4.15-5.01)	3.88 (3.36-4.12)		

SD: Standard Deviation, **IQR:** Interquartile Range, **NS:** Non-Significant, **HS:** Highly Significant.

There was no significant difference between both groups regarding **pre-operative Barthel Index (BI)** and **grades**. In terms of **post-operative Barthel Index (BI)**, the mean was 80.71 ± 8.62 in the decompression alone group and 91.98 ± 7.32 in the decompression with fusion group, with a highly significant improvement in the fusion group (p=0.004). Regarding **post-operative Barthel Index (BI) grades**, moderate dependence was noted in 80.0% of the decompression alone group and 45.5% of the fusion group, slight dependence in 20.0% and 18.2%, and independence in 0.0% and 36.4% respectively (p=0.040) (Table 6).

Table (6): Barthel Index (BI) in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Pre-op Barthel Index (BI)	Mean ± SD	51.20 ± 9.83	58.18 ± 8.68	0.100	NS
	Median (IQR)	48.00 (44.00-55.75)	60.00 (54.50-64.00)		
Pre-op Barthel Index (BI) grades	Severe Dependence	8 (80.0%)	6 (54.5%)	0.440	NS
	Moderate Dependence	2 (20.0%)	5 (45.5%)		
Post-op Barthel Index (BI)	Mean ± SD	80.71 ± 8.62	91.98 ± 7.32	0.004	HS
	Median (IQR)	81.35 (74.82-87.69)	91.75 (88.13-99.57)		
Post-op Barthel Index (BI) grades	Moderate Dependence	8 (80.0%)	5 (45.5%)	0.04	S
	Slight Dependence	2 (20.0%)	2 (18.2%)		
	Independent	0 (0.0%)	4 (36.4%)		

SD: Standard Deviation, **IQR:** Interquartile Range, **NS:** Non-Significant, **HS:** Highly Significant.

The reoperation rate was 30.0% in the decompression alone group and 9.1% in the decompression with fusion group with no statistically significant difference (p=0.508).

In terms of the rationale for reoperation, there was no discernible difference between the groups that experienced wound dehiscence (10.0% in the decompression alone group and 9.1% in the fusion group) and those that had residual infection (20.0% and 9.1%, respectively) (p=0.765). Complications included infection in 20.0% and 9.1% of the decompression alone and fusion groups respectively, and cerebrospinal fluid (CSF) leak in 10.0% and 9.1% of the groups with no significant difference (p=0.716). Following blood loss, anemia was observed in 9.1% and 0.0% of the decompression-only group and the fusion group. The fusion group showed a highly significant improvement in recovery rate (%), with the mean being 60.00 ± 15.22 in the decompression alone group and 81.83 ± 18.75 in the group that used fusion for decompression (p=0.009) (Table 7).

Table (7): Outcome Data in the studied groups

Parameter	Category	Decompression Alone (n=10)	Decompression with Fusion (n=11)	p-value	Significance
Reoperation Rate	Yes	3 (30.0%)	1 (9.1%)	0.508	NS
	No	7 (70.0%)	10 (90.9%)		
Reason for Reoperation	Wound dehiscence	1 (10.0%)	1 (9.1%)	0.765	NS
	Residual infection	2 (20.0%)	1 (9.1%)		
	No	7 (70.0%)	9 (81.8%)		
Complication	CSF leak	1 (10.0%)	1 (9.1%)	0.716	NS
	Infection	2 (20.0%)	1 (9.1%)		
	No	7 (70.0%)	8 (72.7%)		
	Anemia after blood loss	0 (0.0%)	1 (9.1%)		
Recovery rate (%)	Mean ± SD	60.00 ± 15.22	81.83 ± 18.75	0.009	HS
	Median (IQR)	56.00 (50.56-64.29)	86.15 (70.17-98.08)		

SD: Standard Deviation, **IQR:** Interquartile Range, **NS:** Non-Significant, **HS:** Highly Significant.

DISCUSSION

This single-center retrospective cohort study compared decompression with instrumented fusion and decompression alone to evaluate the radiological and clinical outcomes of repeated surgical intervention in patients with deep-seated spine infections after prior spine surgeries. It was conducted at Neurosurgery Department, Faculty of Medicine, Zagazig University. Twenty-one patients participated in the trial, divided into two groups: Decompression only group and decompression with fusion group.

With mean ages of 67.80 ± 3.29 and 68.27 ± 4.27 years in the decompression alone and fusion groups, respectively, the demographic data in our study showed no significant variations in the distribution of ages and genders between the two groups. The results of **Noh *et al.*** [11] who documented a mean age of 71 years in their series of post-operative spinal infections, are similar to this. In contrast to other earlier research, such as **Lee *et al.*** [1]**,** which showed a male predominance in their series (81.5%), our study's gender distribution was almost equal.

There were no significant changes between the groups in our study's preoperative and postoperative laboratory tests, which included inflammatory markers including CRP and ESR. **Noh *et al.*** [11] discovered no significant differences in the inflammatory markers between the decompression group and the decompression plus fusion group for spinal infections, which is in line with this finding. According to this research, ESR/CRP values only show the infection state and not the severity of the infection.

The two groups' operative parameters differed significantly, according to our investigation. The fusion group's procedure lasted 120.11 ± 25.05 minutes, which was significantly longer than the decompression alone group's (85.56 ± 10.92 minutes, p=0.001). **Azizpour *et al.*** [12] found lengthier operative times for decompression and fusion, which is consistent with our conclusion. One drawback of instrumented fusion is the possibility of these results. On the other hand, the growing use of intraoperative CT guidance may reduce the amount of time needed for surgery, which would reduce the rate of complications. **Azizpour *et al.*** [12] reported more blood loss in fusion procedures, and the fusion group experienced substantially higher intraoperative blood loss (517.27 ± 244.58 ml vs. 316.00 ± 115.01 ml, p=0.015).

Our study's VAS pain measurement revealed notable improvements in both groups, with the fusion group achieving noticeably better results for both leg and back pain (p=0.004). The fusion group's post-operative back pain VAS score was 0.80 ± 0.73, while the decompression group's score was 1.93 ± 0.86. In agreement, **Lee *et al.*** [1] found that, with a P value of 0.03, back discomfort was considerably more common in the decompression-alone group (81.5%) than in the decompression and fusion group (50%). Both groups experienced radicular pain, but there was no significant difference between them (22.2% vs. 10%, P = 0.44).

According to our study, the fusion group performed better on functional outcomes measured by the Barthel Index (BI). After surgery, the fusion group experienced a considerably higher BI (91.98 ± 7.32 vs. 80.71 ± 8.62, p=0.004), and 36.4% of patients achieved independence, whereas none of the individuals in the group that only received decompression did.

The findings of an RCT comparing individuals with symptomatic isthmic spondylolisthesis, decompression and fusion with decompression alone were reported by **Azizpour *et al.*** [13]. The results of the randomized patient therapy, two years later, clearly supported decompression and fusion. Both the decompression plus fusion group and the decompression group showed stability following the procedure, according to **Noh *et al.*** [11]**.** According to **Azizpour *et al.*** [12]**,** patients exhibiting symptoms of isthmic spondylolisthesis at the 2-year follow-up benefit more from instrumented fusion in addition to decompression than from decompression alone.

In our study, the fusion group had a lower reoperation rate (9.1%) than the decompression alone group (30.0%), however this difference was not statistically significant. **Dietz *et al.'s*** [9] findings, which showed decreased reoperation rates with instrumented fusion in infected spines, are consistent with this trend. Decompression with fusion had an 8.16% 12-month postoperative reoperation rate, while decompression without fusion had a 12.7% rate. The fusion procedure's 9.1% reoperation rate is comparable to the 6.1%–7.2% rate for various fusion techniques that have been documented in prior research on degenerative spine surgery [14]**.** Therefore, additional re-fusion surgeries are not required when using fusion to treat spinal infections than when using it to treat other spinal problems. According to **Martin *et al.*** [15]**,** fusion has been shown to increase the likelihood of reoperation compared to decompression alone. Nevertheless, we discovered that reoperation was more common following decompression alone than following fusion. According to **Lee *et al.*** [1]**,** Decompression alone versus decompression with instrumented fusion for patients with spinal epidural abscess had different clinical results, complication rates, and reoperation rates. They found that patients who only received decompression had a considerably greater reoperation rate (51.9% vs. 10%, P = 0.004). Similar to our current study, a review by **Karadimas *et al.*** [16] discovered that almost half of patients with spinal infections treated with decompression alone required reoperations, whereas 16.2% of patients who first had decompression plus fusion required reoperations to stabilize their spine.

According to **Dietz *et al.*** [9]**,** the reoperation rate was 12.7% for the non-fusion cohorts and 8.16% for the fusion cohorts. Reoperations were necessary for 12.2% of patients who had decompression alone and 23.8% of patients who had decompression + fusion, according to **Chaker *et al.*** [10]**,** who employed a sizable national database with 738 patients. Although decompression with fusion cohorts and decompression alone did not significantly differ in reoperation rates, **Park *et al.*** [17] and **Baek *et al.*** [18] contend that instrumentation may be a safe treatment option in the case of spinal infection and should be taken into account when spinal instability is a concern. According to **Azizpour *et al.*** [12]**,** the DF group experienced fewer reoperations than the D group. This finding might be influenced by the fact that secondary decompression and fusion is more readily available for patients who experience ongoing leg discomfort following decompression alone, while revision surgery is carried out with greater hesitancy in individuals who have already had primary fusion and decompression.

The most common problems in our study were infection and CSF leak, and the complication profile was comparable between groups. This is consistent with the findings of **Lee *et al.*** [1] who found no significant variations in neurological outcomes or complication rates between groups. However, according to **Dietz *et al.*** [9]**,** the non-fusion group experienced greater difficulties within 30 days (24.64%) than the fusion group (16.49%). According to **Azizpour *et al.*** [12] **and Chan *et al.*** [19]**,** decompression and fusion are linked to issues connected to fusion.

The most notable result was that the fusion group's recovery rate was much higher (81.83 ± 18.75%) than that of the decompression alone group (60.00 ± 15.22%, p=0.009). This significant difference is consistent with the findings of **Lee *et al.*** [1] who observed greater recovery rates with instrumented fusion in similar instances, and implies that adding instrumented fusion to decompression improves overall outcomes in controlling deep-seated spine infections.

The microbiological profile of our investigation revealed that Escherichia coli and Staphylococcus aureus were the most common species. This is in line with previous research [20]**.** However, the fusion group in our study experienced a larger proportion of no growth findings (36.4%) than the decompression alone group (10.0%), which could be related to variations in sample techniques or previous antibiotic therapy.

CONCLUSION

The results of our study collectively implied that in treating deep-seated spine infections after prior spine surgeries, decompression with fusion offered better clinical outcomes, better functional recovery, and possibly lower reoperation rates, even though it took longer to perform and resulted in more blood loss. The better long-term results and increased patient satisfaction seem to outweigh the greater initial surgical cost.

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