Original Article

Conservative versus operative management of postoperative lumbar discitis

ABSTRACT

Background: Treatment option of postoperative discitis (POD) is either conservative or operative, but till date, there are no established validated protocols of the treatment of postoperative lumbar discitis.

Aim: The aim of this study was to assess the outcome of conservative versus operative management of POD following single-level lumbar discectomy.

Methods: We prospectively studied a total of 38 cases of POD. The patients were diagnosed clinically, radiologically, and by laboratory investigations and followed up with serial erythrocyte sedimentation rate (ESR), C-reactive protein, X-ray, computed tomography (CT), and magnetic resonance imaging. Demographic data, clinical variables, length of hospital stay, duration of antibiotic treatment, and posttreatment complications were collected, and pre- and postoperative assessment was done using the Visual Analog Scale (VAS) and Japanese Orthopaedic Association (JOA) score. Functional outcome of the study was measured by the modified criteria of Kirkaldy–Willis.

Results: VAS score for pain was significantly decreased in both groups after treatment. However, posttreatment differences were not statistically significant. In posttreatment mean JOA score, differences were not statistically significant in both groups except the mean difference (0.47) of restriction of daily activities, which was statistically significant (95% confidence interval: 0.88– 0.07, $P = 0.025$, unpaired t-test). About 73.7% and 84.2% of the patients had a satisfactory functional outcome in conservative and operative management groups, respectively, at the end of 12-month follow-up.

Conclusions: Operative management yielded better outcomes than traditional conservative treatment in terms of functional outcomes, length of hospital stays, and duration of antibiotic treatment as determined by both the pain and daily activity levels.

Keywords: Conservative and operative management, lumbar, postoperative discitis

INTRODUCTION

Discitis or disc space infection is an infection or inflammation of the intervertebral disc space or vertebral endplate.[1] Frank Turnbull first described postoperative discitis (POD) in 1953 as a clinical entity.[2] It is a primary infection of the nucleus pulposus with secondary involvement of the cartilaginous endplate and the vertebral body. Iatrogenic cause was described and usually can occur following lumbar discectomies.[3] POD incidence varies from 0.2% to 4%.[4-6] Such type of infections may occur either by open procedure such as laminectomy, discectomy, fusion or instrumented fusions or by minimally invasive spinal procedure such as discography, myelography, paravertebral injection, lumbar puncture etc.[6]

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It can be septic or aseptic, but recent data suggest that POD is mainly septic bacterial infections.[3,7]

The most common symptom of discitis is constant back pain that worsens at night and gradually increasing from mild to severe excruciating pain after an initial postsurgical relief of pain. It may be associated with radiating pain to buttocks, thighs, legs, scrotum, groin or perineum,[8] and constitutional symptoms such as fever, fatigue, and malaise (11%–68% of cases).[9-11] Postoperatively, back pain usually develops (1–6 weeks).[3,8] While neurological deficits are uncommon, spinal tenderness is the most common sign detected on examination associated with restricted range of movement, pseudo-Gower sign (difficulty rising from bed), paravertebral muscle spasm, and loss of lumbar lordosis.[5,8,11] Hence, a high index of suspicion is necessary for every patient presenting with back pain after spinal surgery to start early diagnosis and treatment of discitis; otherwise, this can lead to increased morbidity and mortality.[3,8,12,13]

Treatment options of POD are either conservative or operative, but till now, there are no established, validated protocols of the treatment of postoperative lumbar discitis. Although the mainstay for discitis treatment is a combination of bed rest and prolonged administration of antibiotics, the dosage, route, and duration of antibiotic therapy advocated by various investigators are still imprecise. Thus, surgical intervention is occasionally necessary for patients with failing conservative treatment.[3,8,12]

The duration of medical therapy is variable. Some authors advocate 6–8 weeks of intravenous therapy alone, whereas others propose 6–8 weeks of intravenous antibiotics, followed by 2 months or more of oral therapy, depending on clinical and laboratory responses.[3,8,12,14] The prolonged period of antibiotic therapy and strict bed rest can lead to undesired medical and psychosocial effects.[15,16] Unfortunately, there are no prospective, randomized studies or sufficient data in the literature to compare conservative management outcomes versus surgical treatment. Moreover, most of the surgically treated patients developed severe painful deformities and neurological impairments.

We present this prospective study to assess the outcome of conservative versus operative management of POD following single-level lumbar discectomy, which might be helpful to provide evidence-based information to physicians as well as patient groups regarding the appropriate treatment option for POD.

METHODS

This prospective study was conducted in the Department of Orthopaedic Surgery, BSMMU, Dhaka, from January 2017 to May 2020. Ethical clearance was obtained from the Institutional Review Board of BSMMU (ref. no. 11403), and informed written consent was taken from all patients before their inclusion in the study. The inclusion criteria for this study were as follows: (1) patients with diagnosed POD following single-level lumbar discectomy; (2) time framework for the development of back pain after 1–6 weeks of surgery; and (3) POD with radiculopathy. The exclusion criteria in this study were as follows: (1) patients with spontaneous discitis, (2) patients with multiple-level discectomy, (3) patients who lost following up during the 12 months after their discharge, (4) patients who started medical management before shifting to surgical treatment due to inadequate antibiotic response, and (5) patients with gross spinal instability.

A total of 38 cases of POD with applied inclusion criteria were taken as samples. Records of 12 men and 7 women aged 26–65 (mean, 42.53 ± 10.40) years who underwent conservative treatment for pyogenic POD (Group A) after single-level open discectomy at L3–L4 ($n = 3$), L4–L5 ($n = 12$), and L5–S1 ($n = 4$) and 14 men and 5 women aged 26–65 (mean, 45.95 ± 11.90) years who underwent operative treatment for POD (Group B) following single-level open discectomy at L3–L4 ($n = 2$), L4–L5 ($n = 14$), and L5–S1 ($n = 3$) were reviewed. All patients were treated in our spine unit by a single surgeon, and out of 38 patients, 12 patients were referred from other hospitals. All primary discectomy patients had a history of given two antibiotics (intravenous ceftriaxone plus flucloxacillin), 1 h before induction for 2 days, followed by another 5 days of oral antibiotics during discharge (including patients referred from other hospitals in our study). These patients were diagnosed clinically, radiologically, and by laboratory investigations.

All patients had constant back pain that worsens at night or gradually increasing from mild to severe excruciating pain described as continuous, deep seated, and associated with morning stiffness. This presentation was accompanied by severe paravertebral muscle spasm radiating to buttocks, thighs, groin, perineum, or abdomen. Typically, this pain was easily exacerbated by any motion (even with a gentle tap on the bed). On examination, they had severe restriction of movements, positive pseudo-Gower sign, and straight leg raising (SLR) test. Blood parameters such as complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), blood culture, and other blood investigations (blood sugar, serum albumin, liver, and renal function tests) were done.

Radiological investigations such as X-rays and lumbosacral anteroposterior and lateral spine views were done to document endplate erosion, cavitation, reduction in disc space, and instability, followed by computed tomography (CT) if the previous failed to provide a definitive diagnosis, and magnetic resonance imaging (MRI) with gadolinium contrast enhancement was serially done for evaluation of response to treatment. CT-guided aspiration of the disc space (using a needle or trocar) for microscopy, culture, and biopsy was also performed to identify the bacterial pathogens. All hematological investigations, blood cultures, and CT-guided aspiration of the disc space were done just after admission and before starting empirical antibiotic treatment. Then, cases were followed up at 2 weeks, 1 month, 3 months, 6 months, 12 months, and yearly after that, with serial CBC, ESR, CRP, and repeated X-rays. CT, MRI, or both were done in some patients [Figure 1d-f].

Patients who met the inclusion criteria with almost similar general health status were divided into two groups, as they were numbered in series according to their admission. Those with an odd serial number were classified as Group A, whereas patients with even numbers were classified as Group B. Furthermore, patients in Group A consisted of 19 patients receiving conservative treatment (4–6) weeks of intravenous antibiotics, followed by an additional 4–6 weeks of oral antibiotics, or until back pain, ESR, and CRP values were significantly improved, along with strict bed rest, nutritional diet, analgesic, orthosis, and physiotherapy. Group B consisted of 19 patients receiving operative treatment in the form of exploration and debridement only, a combination of debridement and fixation with posterolateral fusion, and transforaminal lumbar interbody debridement with fusion by titanium cage and autogenous bone graft and stabilization by pedicle screw and rod. After operation patients were treated by 2-3 weeks of intravenous antibiotics followed by 3 weeks of oral antibiotics or untill back pain, ESR and CRP values significantly improved.

Immediately after sending hematological investigations, blood culture, and CT-guided disc space aspiration, all patients started empirical intravenous antimicrobial therapy (ceftriaxone/meropenem with flucloxacillin for Gram-positive and Gram-negative organisms and metronidazole for anaerobic coverage). Then, an appropriate antibiotic was administrated according to the results of microbial culture and sensitivity. The dosage and treatment durations were based on the patient's weight and his/her renal and liver functions. The antibiotic therapy was withdrawn based on clinical improvements and the infection-related laboratory test results, such as the average levels of CRP and ESR.

The surgical method for each surgery is primarily dependent on surgeons' preferences, by which surgeons chose the approach and type of surgery they are most familiar with according to the situation of the infected site in the spine. Demographic data, clinical variables, length of hospital stay, duration of antibiotic treatment, tissue culture reports, and posttreatment complications were recorded. Pre- and postoperative assessments were done using the Visual Analog scale (VAS) or the Japanes Orthopaedic Association (JOA) score. The functional outcome of the study was measured by the modified criteria of Kirkaldy–Willis [Table 1]. All the data were analyzed statistically using the Statistical Package for the Social Science (SPSS, version- 25, Armonk, NY, IBM Corp.). The results were expressed as frequency, percentage, and mean ± standard deviation (SD). Paired and unpaired Student's *t*-test, Chi-square test, Fisher's exact test, and *Z* proportion test were performed as applicable. The level of significance was calculated at a confidence interval of 95% and $P < 0.05$. All the patients were followed up and evaluated at least 12 months postoperatively.

Surgical procedure

Following general anesthesia, all patients were positioned prone on frames or rolls to avoid abdominal compression and venous congestion. After adequate prepping, sterile washing, and draping, a posterior longitudinal incision was made, taking off the old surgical wound. All the revision surgeries were performed from the same site of the primary surgery. The epidural scar tissue from the previous surgery was separated from the margin of the residual lamina, and then, access to the normal anatomic planes of the epidural space was achieved by removing the residual lamina. The posterior elements were exposed, and the epidural scar tissue was detached and resected, showing the exposed dura and nerve roots on both sides. These neural structures were carefully dissected and lifted off the posterior longitudinal ligament using bipolar cautery. The nerve roots were then mobilized gently and retracted medially to expose the disc fragments. Then, the affected intervertebral disc was exposed and curetted out on one side, followed by the other. All visible inflammatory tissues were debrided, and disc space

Table 1: The modified criteria of Kirkaldy–Willis for the functional outcome

Grade	Description
Excellent	The patient has returned to his routine work and other activities with little or no complaint
Good	The patient has returned to his routine work but may have some restriction in other activities and may on occasion after heavy work have recurrent back pain requiring rest for a few days
Fair	The patient has to reduce his working capacity, take a lighter job or work part-time, and occasionally have a recurrence of pain requiring absence from work for 1–2 weeks, once or twice a year
Poor	The patient does not return to work

and wound area were irrigated adequately by gentamicin mixed with normal saline solution (NaCl 0.9%), followed by interbody fusion with titanium banana cage and autogenous cancellous bone grafts or posterolateral fusion by bone graft depending on the vertebral body destruction, collapse, and kyphotic deformity.

Posterior instrumentation was carried out with pedicle screws, and rods and vertebral bodies above and below the affected segment were included; then, perioperative smears and tissue samples were taken for histological and microbiological assessment. Out of 19 patients, 8 patients were treated by debridement only, 5 patients by posterolateral fusion and posterior instrumentation, and 6 patients by interbody fusion with titanium banana cage and autogenous cancellous bone grafts and posterior instrumentation. Finally, the closure was then done in a routine fashion after the insertion of a subcutaneous suction drain. Besides, all patients received empirical broad-spectrum antibiotics perioperative. Then, appropriate antibiotics were administered according to the microbial cultures and sensitivities, and patients were encouraged to ambulate on the 3rd or 4th day after surgery and were followed up 2 weeks, 1 month, 3 months, 6 months, 12 months, and then once every year.

RESULTS

The mean follow-up periods were 14.8 months (range was 12–24 months) and 13.6 months (range was 12–24 months), and the mean pain-free interval after primary discectomy was 3.2 weeks (range was 1–6 weeks) and 3.6 weeks (range was 1–8 weeks) in the conservative and operative groups, respectively. Furthermore, the mean duration of symptoms before admission to the conservative group was 8.8 days (range was 5–21 days) and the operative group was 9.5 days (range was 7–21 days). All patients had moderate ($n = 8$) to severe back pain ($n = 30$), radiculopathy ($n = 18$), mild fever ($n = 10$), paravertebral muscle spasm ($n = 26$), SLR test positive ($n = 24$), and pseudo-Gower sign ($n = 15$), and the surgical site skin incision appeared to be normal in all patients. Local erythema, swelling, or a draining sinus was not seen except in one patient in the conservative group during the treatment period.

Among 38 patients, there were 5 service holders in each of the two groups (26.3%), 7 businessmen in the conservative group (36.8%) and 6 in the operative group (31.6%), and 3 homemakers in the conservative group (15.8%) and 4 in the operative group (21.1%). Furthermore, in each of the two groups, there were four patients with other occupations (21.1%) [Table 2].

Associated risk factors were as follows: chronic smoking as found in five patients in both the groups (26.32%), obesity (body mass index >30 kg/m^2) as in six patients in the conservative group (31.58%) and eight patients in the operative group (42.11%), and diabetes mellitus with good glycemic control as found in seven patients in the conservative group (36.84%) and six patients in the operative group (31.57%). There were no other comorbidities such as rheumatoid arthritis, immunosuppression, collagen vascular diseases, widespread malignancy, or any comorbidity mandating steroid intake in any of our cases. However, there was only one malnourished patient (5.26%) in the conservative group.

The demographic characteristics in both the groups statistically showed no significant differences in age, sex, occupation, clinical presentation, pain-free interval for the development of symptoms of discitis, duration symptoms, disc level, and associated risk factors [Table 2]. ESR and CRP values were increased in all patients; 14 of 38 patients had white blood cell counts above 11,000/mm^3, three patients had total lymphocyte count <1500/mm, and one patient had albumin level below 3.5 g/dl. The mean pretreatment ESR was 60.32 ± 18.02 and 62.11 ± 17.23 mm/h and posttreatment ESR was 14.37 ± 2.29 and 12.68 ± 1.94 mm/h in both the groups, respectively. The mean pretreatment CRP was 70.68 ± 19.82 and 72.84 ± 20.93 mg/L and posttreatment was 8.10 ± 2.97 and 6.21 ± 1.65 mg/L in both Groups A and B, respectively. However, after treatment, elevated ESR and CRP values of patients in both the groups started to decrease within (1–2) weeks, and elevated values returned to the preoperative baseline within 1–3 months. Finally, these values returned to normal in all patients within 6 months during follow-up [Table 3].

In the conservative group, blood culture and CT-guided aspiration isolated 63% of organisms; 58.3% were *Staphylococcus aureus*, 33.3% were *Staphylococcus epidermidis*, and 8.3% were *Escherichia coli*. However, in the operative group, blood culture, CT-guided aspiration, and postoperative tissue biopsy isolated 73.7% of causative organisms. Among them, 57.1% were *S. aureus*, *S. epidermidis* 21.4%, *E. coli* 7.1%, *Pseudomonas* 7.1%, and *Enterococcus* 7.1% [Table 3]. Their biopsy reports showed a mixture of inflammatory cells, including neutrophils, plasma cells, and lymphocytes, but no granulomatous lesions [Table 3].

All patients obtained plain X-ray (anteroposterior and lateral views). Earlier reports showed little evidence of discitis (except for some reduction in disc space). On the other hand, 6–8 weeks later, they showed localized

Table 2: Demographics in patients with conservative and operative management groups

Characteristics	Conservative, Group A (n=19)	Operative, Group B (n=19)	*P*
Mean age (years)	42.53±10.40 (range, 26-65)	45.95±11.90 (range, 26-65)	0.804^{ns}
Sex			
Male	12 (63.2)	14 (73.7)	0.485^{ns}
Female	7 (36.8)	5 (26.3)	
Occupation			
Service holder	5 (26.3)	5 (26.3)	0.804^{ns}
Businessman	7 (36.8)	6 (31.6)	
Homemakers	3 (15.8)	4 (21.1)	
Others	4 (21.1)	4 (21.1)	
Clinical presentation			
Back pain	19 (100)	19 (100)	1.000^{ns}
Leg pain	8 (42.10)	10 (52.6)	0.516^{ns}
SLRT	12 (63.2)	12 (63.2)	1.000^{ns}
Muscle spasm	12 (63.2)	14 (73.7)	0.483^{ns}
Pseudo-Gower sign	7 (36.84)	8 (42.10)	0.482^{ns}
The pain-free interval of development of symptoms of discitis			
Within 1-2 weeks	3 (15.8)	2 (10.5)	0.631^{ns}
>2-8 weeks	16 (84.2)	17 (89.5)	
Involved level			
L3-L4	3 (15.8)	2 (10.5)	0.780^{ns}
L4-L5	12 (63.2)	14 (73.7)	
L5-S1	4 (21.1)	3 (15.8)	
Risk factors			
Smoking	5 (26.32)	5 (26.32)	0.931^{ns}
Obesity	6 (31.58)	8 (42.10)	
DM	7 (36.84)	6 (31.58)	
Malnourished	1 (5.26)	0	
Mean duration of symptoms (days)	8.8 (range, 5-21)	9 0.5 (range, 7-21)	
Mean follow-up (months)	14.8 (range, 12-24)	13.6 (range, 12-24)	

SLRT - Straight leg raising test; DM - Diabetes mellitus

Table 3: Inflammatory markers (blood culture, aspiration, and tissue biopsy in Group A and Group B)

Blood parameters	Group A (n=19)	Group B (n=19)	*P*
Mean ESR (mm in the 1st h)			
Pretreatment	60.32±18.02 (41-91)	62.11±17.23 (41-74)	0.756^{ns}
Posttreatment			
2 weeks	52.00±14.31	30.63±6.57	<0.001*
1 month	40.68±9.48	25.42±3.91	<0.001*
3 months	28.00±4.18	20.89±5.41	<0.001*
6 months	17.42±3.29 (12-26)	15.16±3.85 (12-22)	0.059^{ns}
12 months	14.37±2.29	12.68±1.94	0.020
Pre versus Post -treatment p value at 12 months (*P*)	<0.001*	<0.001*	
Mean CRP (mg/L)			
Pretreatment	70.68±19.82 (39-93)	72.84±20.93 (49-90)	0.746^{ns}
Posttreatment			
2 weeks	60.47±11.48	32.37±8.47	<0.001*
1 month	42.18±7.82	20.89±8.92	<0.001*
3 months	23.89±3.36	13.37±3.40	<0.001*
6 months	12.16±3.35 (7-25)	10.16±2.93 (7-16)	0.058^{ns}
12 months	8.10±2.97	6.21±1.65	0.020
Pre versus post-treatment p value at 12 months (*P*)	<0.001*	<0.001*	
Blood culture positive total of 18 patients (47.37%)	10 (52.63%)	8 (42.11%)	
S. aureus	6 (31.58%)	5 (26.32%)	
S. epidermidis	3 (15.79%)	2 (10.53%)	

Contd...

Table 3: Contd...

Blood parameters	Group A (n=19)	Group B (n=19)	*P*
E. coli	1 (5.26%)	1 (5.26%)	
Disc space aspiration, 22 cases (57.89%) positive	12 (63.16%)	10 (52.63%)	
S. aureus	7 (36.84%)	6 (31.58%)	
S. epidermidis	4 (21.05%)	3 (15.79%)	
E. coli	1 (5.26%)	1 (5.26%)	
Tissue biopsy (aspiration and post operative tissue/culture/gram staining)	Mixture of inflammatory cells	Mixture of inflammatory cells Growth - 6 cases *Staphylococcus* - 4, *Pseudomonas* - 1 *Enterococcus* - 1	
Total isolation of organism 26 cases	12 (63.16%) cases	14 (73.68%) cases	

[ns]Not significant, *Significant. *S. aureus* - *Staphylococcus aureus*; *S. epidermidis* - *Staphylococcus epidermidis*; *E. coli* - *Escherichia coli;* ESR - Erythrocyte sedimentation rate; CRP - C-reactive protein

osteopenia, narrowing of the disc space, endplate erosion, cavitation, and kyphotic deformity. Dynamic X-ray was only done if the patient tolerated the pain. However, CT scans were done only for 26 out of 38 patients (68.42%) as this was a financial burden for the remaining 12 patients, which showed that endplate erosions suspected to be formed 3–6 weeks before.

The characteristic MRI findings of discitis were found in all of the patients as they appeared hypointense on T1-weighted images and hyperintense on T2-weighted images with diffuse and continuous heterogeneous contrast enhancement of the discs, endplate, and adjacent marrow [Figures 1a-c and 2a,b], which mimic Modic type 1 changes or immediate postoperative period (<6 weeks) changes or recurrent disc herniation. The early pathognomonic sign of disc space infection is a disc within the disc [Figure 2c]. Severe pain after a pain-free interval following lumbar discectomy raises the possibility of a recurrent disc herniation. However, it is difficult to distinguish between a recurrent disc with postoperative changes and scar tissue via MRI, not before 6 months after surgery.[17] A recurrent disc appears on contrast MRI as a rarely enhancing, smooth polypoid, or lobulated margin, which can be contiguous with the remaining disc or appearing as a free fragment. Hence, it exerts a mass effect on the thecal sac and nerve roots.[18] On the other hand, the postoperative scar tissue is irregular, does not have a mass effect, noncontiguous with the disc, and enhances brightly with contrast.[18,19]

In the conservative group, 14 out of 19 patients (73.69%) improved with 30–42 days (4–6 weeks) of intravenous antibiotic use, followed by 35 days (5 weeks) of oral antibiotic use. However, another five patients required 42–49 days (6–7 weeks) of intravenous antibiotic use, followed by another 35–42 days (5–6 weeks) of oral antibiotic use, until the pain was relieved, and the acute-phase reactants had normalized. The mean duration of antibiotic use (both intravenous and oral) was 78.00 ± 5.35 (range, 69–92) days in Group A. However, in the operative group, all patients improved within 14–21 days of intravenous antibiotic use postoperatively, followed by oral antibiotics for 21–28 days, until pain, ESR, and CRP values significantly improved. The mean duration of administration of both intravenous and oral antibiotics was 40.15 ± 3.48 (as a range between 34 and 50) days in Group B.

Based on cultures and sensitivity tests, meropenem, flucloxacillin, linezolid, and fusidic acid were sensitive for *S. aureus* and *S. epidermidis,* whereas ciprofloxacin and tobramycin were found to be sensitive for *E. coli*, *Enterobacter* species, and *Pseudomonas*. However, a third-generation cephalosporin (ceftriaxone) was used as an empirical antibiotic and during primary surgeries was found to be resistant to *S. aureus* and *S. epidermidis* and *E. coli* in 40% of cases. Hence, all patients received intravenous empirical antibiotics initially, followed by culture-specific antibiotics.

The conservative group was treated with antibiotics, analgesics, orthosis, and physiotherapy. Nevertheless, the operative group was treated with surgical intervention in the form of debridement alone in eight patients (42.1%), debridement with posterolateral fusion by autogenous bone graft and stabilization by pedicle screw and rod in five patients (26.3%), and transforaminal lumbar interbody debridement with fusion by titanium cage and autogenous bone graft and stabilization by pedicle screw and rod in six patients (31.6%), followed by antibiotics, analgesics, and orthosis [Figure 2d and e].

The pretreatment mean (±SD) VAS score was 7.16 (±1.98) and 7.53 (±1.73) in both the groups and posttreatment mean (±SD) VAS score was 2.47 (±1.93) and 1.32 (±1.59), respectively, and the *P* value was 0.543[ns] and 0.053[ns],

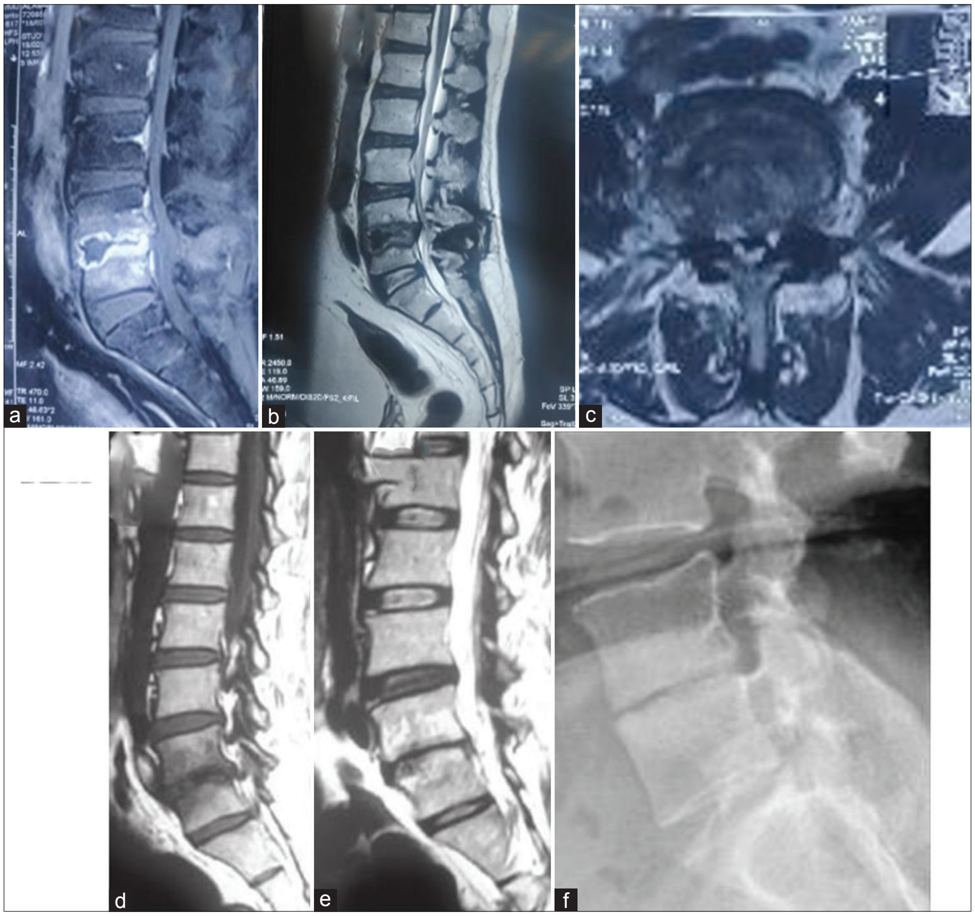

Figure 1: (a and b) T1 and T2 sagittal and (c) axial images of postoperative spondylodiscitis. (a and b) Acute stage with altered vertebral marrow signal intensity and associated endplate erosion. (d and e) Partially healed stage with minimum residual paradiscal vertebral marrow edema after 14 weeks. Conservative treatment (f) plain X-ray shows narrowing of disc space with healing after 2 years

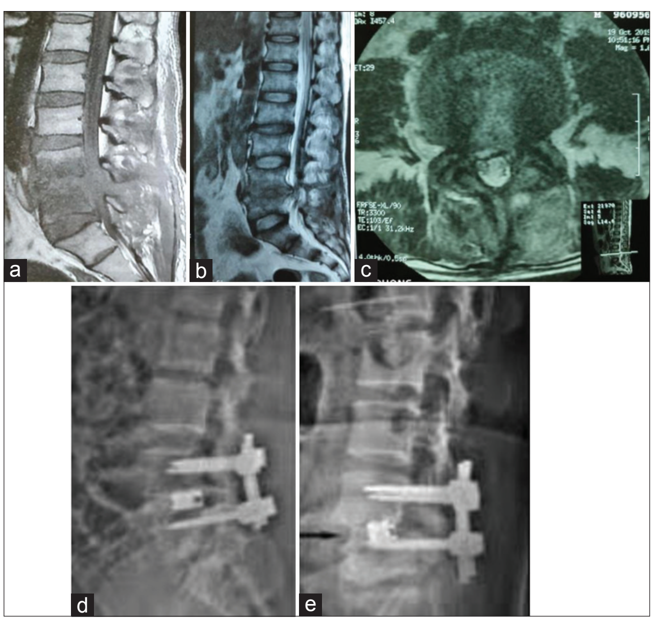

Figure 2: (a and b) T1 and T2 sagittal and (c) axial images of postoperative discitis with altered vertebral marrow signal intensity and associated endplate erosion. (d and e) transforaminal lumbar interbody fusion with titanium cage with bone graft and stabilized by pedicle screws, follow-up at 6 months, and 15 months with union

respectively. The pain was significantly decreased in both the groups after treatment. Nevertheless, posttreatment differences were not statistically significant [Table 4]. The mean overall JOA score of the patients improved significantly from 8.79 ± 3.03 to 23.00 ± 2.87 postoperatively with an estimated mean difference of − 14.21 (95% confidence interval [CI]: −16.57–−12.78, $P < 0.001$) in Group A and from 9.16 ± 3.08 to 23.95 ± 2.72 in Group B with an estimated mean difference of − 14.79 (95% CI: −16.58–−13.00, $P < 0.001$). However, posttreatment (JOA) score, mean differences were not statistically significant in both the groups (mean difference: −0.95, 95% CI: −1.12–0.07, $P = 0.166^{ns}$) except for the mean difference (−0.47) of restriction of daily activities, which was statistically significant (95% CI − 0.88–−0.07, $P = 0.025^{s}$) [Table 4]. The mean (±SD) length of hospital stay was 52.32 (±6.51) days in Group A and 30.11 (±4.41) days in Group B.

POD symptoms were reduced without any complications in 12 (63.2%) and 17 (89.5%) patients in Groups A and B, respectively. In Group A, 7 (36.8%) patients developed

Table 4: Clinical and functional outcome assessment by VAS, JOA and modified criteria of Kirkaldy-Willis

Clinical criteria	Group A (*n*=19)		*P*	Group B (*n*=19)		*P*
	Pretreatment	Posttreatment after 1 year		Pretreatment	Posttreatment after 1 year	
VAS for back pain	7.16±1.98	2.47±1.93	0.001s	7.53±1.73	1.32±1.59	0.001s

Pre- versus pre- and post- versus posttreatment *P* value in Group A and B 0.543ns and 0.053ns, mean difference 0.37, 1.15, 95% CI: −0.853-1.593 and−2.313-0.013

JOA score criteria	Group A (*n*=19)		*P*	Group B (*n*=19)		*P*
	Pretreatment	Posttreatment		Pretreatment	Posttreatment	
Low back pain	0.26±0.45	1.95±0.71	<0.001s	0.42±0.51	2.05±0.62	<0.001s
Leg pain and or tingling	0.26±0.45	1.95±0.71	<0.001s	0.32±0.48	1.95±0.71	<0.001s
Ability to walk	0.26±0.45	1.95±0.71	<0.001s	0.26±0.45	2.11±0.74	<0.001s
SLRT	0.26±0.45	1.42±0.51	<0.001s	0.26±0.45	1.53±0.51	<0.001s
Sensory disturbance	0.84±0.37	1.63±0.50	<0.001s	0.74±0.45	1.79±0.42	<0.001s
Motor disturbance	0.26±0.45	1.74±0.45	<0.001s	0.37±0.50	1.68±0.48	<0.001s
Restriction of daily activities	7.26±0.81	12.37±1.17	<0.001s	7.26±0.81	12.84±1.17	<0.001s
Urinary bladder function	−0.63±1.26	0.00±0.00	0.042s	−0.47±1.12	0.00±0.00	0.083ns
Total JOA score*	8.79±3.03	23.00±2.87	<0.001s	9.16±3.08	23.95±2.72	<0.001s

No significant difference of mean total JOA score between posttreatment Group A and Group B (mean difference: −0.95, 95% CI: −1.12–0.07, *P*=0.166ns) but mean difference (−0.47) of restriction of daily activities were statistically significant (95% CI: −0.88–−0.07, *P*=0.025s)

Functional outcome according to modified criteria of Kirkaldy-Willis at 12 months

	Group A (*n*=19), *n* (%)	Group B (*n*=19), *n* (%)	*P*
Excellent	6 (31.58)	9 (47.4)	0.613ns
Good	8 (42.11)	7 (36.8)	
Fair	4 (21.05)	3 (15.8)	
Poor	1 (5.26)	0	
Satisfactory	14 (73.69)	16 (84.2)	0.692ns
Unsatisfactory	5 (26.31)	3 (15.8)	

sSignificant; nsNot significant. VAS - Visual Analog Scale; JOA - Japanese Orthopedic Association Score; CI - Confidence interval

complications; among them, wound infection was found in one patient (5.3%), urinary incontinence was found in one patient (5.3%), persistent pain was found in one patient (5.3%), and other four patients developed complications due to longer duration of antibiotic therapy (26.3%), two of whom developed drug-induced hepatitis: one developed phlebitis (at intravenous cannula site) and one developed increased serum urea and creatinine, suggestive for renal pathology. Fortunately, all patients gradually improved over 8 weeks. Only one patient had persistent pain and difficulty walking due to the collapse of disc space and kyphotic deformity persisting after 6 months of follow-up, even after taking 12 weeks of antibiotic therapy and bed rest. Subsequently, this patient was advised to undergo operative treatment.

In Group B, one patient (5.3%) developed an allergic reaction due to antibiotic use, and one patient (5.3%) developed postoperative superficial wound infection, which was managed accordingly [Table 5]. All patients were regularly followed up with serial blood tests/X-rays after 1, 3, 6, and 12 months after discharge and then once every year after that [Figure 1f,2d and e]. Fusion status was evaluated at 6 and 12 months by radiography and CT scan postoperatively. Fortunately, none of the patients during the conservative and operative treatment suffered neurological deterioration.

Compared to the conservative group (Group A), even though the operative group (Group B) required a significantly shorter hospital stay, shorter duration of bed rest, and shorter antibiotic duration, there was a reduction in their discitis symptoms with fewer complications. However, blood transfusions (63.16% vs. 31.58) and total cost of the treatment procedure (115,000/$ 1352 vs. 80,000/$ 940) were more in the operative group than in the conservative group. Thus, according to the modified criteria of Kirkaldy–Willis, 6 (31.58%) and 9 (47.4%) patients had excellent results, 8 (42.11%) and 7 (36.8%) patients had good results, 4 (21.05%) and 3 (15.8%) patients had fair results, and 1 (05.26%) and 0.0% patients had poor results in both the groups, respectively. The satisfactory rate was 73.69% in Group A and 84.2% in Group B [Table 4] at the end of the 12-month follow-up.

DISCUSSION

Postoperative disc space infection is a dreaded complication of disc surgeries, associated with significant morbidity, mortality, and an increase in the cost of health care. Intervertebral discs are largely avascular and derive their

Table 5: Surgical data and complications in Group A and Group B

Characteristics	Conservative Group A (*n*=19)	Operative Group B (*n*=25)	*P*
Mean operative time (min)		135 (range 90-180)	
Length of hospitalization (days)	52.32±6.51 (45-65)	30.11±4.41 (25-37)	0.001
Length of antibiotic treatment (I/V + oral) (days)	78.00±5.35 (69-92)	40.15±3.48 (34-50)	0.001
Need for blood transfusion	6 (31.58%) patients	12 (63.16%) patients	
No complications	12 (63.2%)	17 (89.5%)	0.124
Complications	7 (36.84)	2 (10.53%)	0.124
Wound infection	1 (5.26%)	1 (5.26%)	
Urinary incontinence	1 (5.26%)	0	
Persisting pain	1 (5.26%)	0	
Others due to antibiotics, e.g., allergic reaction			
Phlebitis	4 (21.05%)	1 (5.26%)	
Total cost of the procedure	Taka 80,000 ($940)	Taka 115,000 ($1352)	<0.001

I/V - Intravenous

nutrition from the vertebral endplates and through the cartilaginous endplates by diffusion from capillary plexuses.[20] The avascular nature of the disc leaves it vulnerable to the iatrogenic introduction of bacteria during interventional disc procedures.[21] This can be either septic or aseptic, where aseptic discitis arises as a result of traumatization of the disc causing vascular compromise during surgery.[22] However, many studies showed that POD could be due to bacterial causes.[3,7,10,23] Most patients of POD can be managed conservatively with immobilization (bed rest and orthosis) and analgesic along with intravenous antibiotic therapy.[24-26] However, surgery can only be recommended when there are complications such as neurological impairment, severe pain, abscess formation, spinal instability (due to extensive bony destruction), severe kyphosis, or failure of nonsurgical management.[27-29]

Even though the traditional conservative treatment produces a good outcome in the majority of patients, the prolonged period of strict bed rest and antibiotic therapy which can last up to several months might lead to undesired medical and psychosocial consequences[8,30,31] and antibiotic-related major complications (colitis, renal failure, allergic reactions, and phlebitis).[32] However, patients treated with antibiotics have no risk of surgery-related complications. Nevertheless, prolonged antibiotic treatment may not be effective where some degree of vertebral body destruction, nerve root impingement, progressive kyphosis, and prolonged back pain may still occur after successful treatment.

On the other hand, early surgery can achieve infection control and immediate pain relief in advance of extensive vertebral destruction leading to spinal instability and kyphotic deformity, but patients may still suffer from procedure-related complications. However, following conservative treatment, the overall long-term prognosis is good, with reported success rates of 70%–83%.[3,4,10] Furthermore, one study reported that 90% of patients are pain free after the resolution of the infection, with 75% going on to either bony ankylosis or stable fibrous union within 2 years of their infection. In contrast, a recent study reported that following conservative treatment, in only 35% of cases, bony ankylosis occurs within 2-year period, and most of the patients frequently complain of residual mechanical back pain.[33,34]

A study by Hadjipavlou *et al*. shows that 64% of patients treated with medical means complained of mechanical back pain as opposed to 26% of patients treated surgically.[35] Furthermore, those patients failing nonoperative management usually have progression and spread of their infection with worsening symptoms and elevated laboratory markers and the development of significant spinal deformity. These two clinical scenarios often require operative intervention. A recent study reported good results in 17 consecutive patients treated operatively with debridement, autologous bone grafting, and internal fixation at a mean follow-up of 30 months.[36] Our study is a prospective study that assesses the outcome of conservative versus operative management of POD following single-level lumbar discectomy, which might help provide evidence-based information to the physician and patient groups about the appropriate treatment option for POD.

Compared to the conservative group (Group A), the operative group (Group B) required a significantly shorter hospital stay, shorter duration of bed rest, and antibiotic therapy, and their symptoms of discitis were reduced more with fewer complication rates. Similar findings were almost observed in other studies.[3,37-39] The overall functional outcome for patients who received operative treatment at the end of 12-month follow-up was 84.2%, whereas in the conservative treatment group, it was 73.69%. A study by Chang *et al*.[39] and Das *et al*.[40] showed that satisfactory outcomes were 80% and 100% in the operative management group. Based on our results, we suggest that all patients at an early stage of pyogenic POD (within 3 weeks of the onset of symptoms) and suitable for surgery should be treated surgically by debridement immediately after the confirmation of the diagnosis to achieve better outcomes. However, those who are in late stages with neural element compression, instability, and kyphotic deformity and then radical and aggressive debridement, fusion, and instrumentation must be initiated for improvement or maintenance of sagittal balance.[25,27-29,35] Hence, conservative treatment is indicated if the patient is not suitable for surgery.

Other authors have advocated that early surgical debridement, followed by antibiotics, is superior to the traditional treatment with antibiotics alone.[41,42] Similarly, in cases of conservative treatment, if treatment starts within 2 weeks of the onset of symptoms, then 6 weeks of treatment is sufficient, but when treatment is delayed for a mean of 6–7 weeks after the onset of symptoms, then antibiotic treatment for 4–8 weeks is associated with an increased recurrence rate as compared with treatment for 12 weeks and more.[14]

The reasons for improved surgery outcomes with antibiotic groups most likely reflect the nature of the disease itself since the most critical issue in the treatment of pyogenic POD is the infection itself and the resultant spinal instability. Undoubtedly, antibiotics are effective for infection treatment, but they may be relatively ineffective in correcting spinal instability. Surgery, in contrast, can be used to remove inflammatory debris tissues and provide enhanced spinal stability, as well as for obtaining tissue for histopathological examination, Gram/acid-fast bacilli staining, and accurate bacterial culture laboratory tests. Thus, it is the combination of surgery and antibiotics that may result in better outcomes than treatment with antibiotics alone, as this combination provides treatment of both the infection and the spinal instability at the same time.

Surgery at the L4/5 and L5/S1 level through anterior approach is quite difficult and morbidity is high, so all surgery for POD cases were performed through the posterior approach. Re-exploration, debridement and curettage of disc space granulation tissue were done in all cases but inter-transpedicular fixation were done only in 11 cases. The disc space can be approached more easily from the posterior side. However, despite an active infection, instrumentation after radical debridement will not increase the risk of recurrent infection. Moreover, instrumentation helps in stabilizing the infected spine more effectively and hastens the healing process.[43,44] Another study by Przybylski and Sharan[36] reported that single-stage debridement, arthrodesis, and internal fixation could be used as surgical management of pyogenic discitis with vertebral osteomyelitis without much complication.

The primary aim of the surgical technique is debridement with biopsy for culture and histology. However, following decompression, drainage, and sequestrectomy, the spine may become unstable. Thus, mechanical stabilization is needed in the same or subsequent operations. Nowadays, two different surgical philosophies can be applied: less invasive surgery (LIS) or classic open surgery. The open surgery approach is still the gold standard nowadays, especially if massive bone destruction is evident, whereas LIS can either be CT scan guided or endoscopy guided, which is technically demanding but offers good results when applied early.[35] Moreover, the percutaneous transpedicular discectomy and drainage will result in immediate pain relief.[45]

In all of our 19 operatively treated patients, 8 patients were treated by exploration and debridement only, 5 patients by a combination of debridement and instrumentation with posterolateral fusion, and 6 patients by interbody fusion with titanium banana cage and autogenous cancellous bone grafts and posterior instrumentation depending on the duration of onset of symptoms, severity of pain, and resultant instability. Almost all patients were mobilized within 48–72 h after surgery. None of them had any neurological deterioration except one patient who developed superficial wound infection. Finally, all patients returned to their normal daily activities within 6 months.

The incidence of fusion with bone graft is 97%, compared to the 90% debridement alone or chemotherapy alone without surgery, which achieves a solid fusion in 65%–79% of cases.[46] Careful re-exploration, debridement, and transpedicular fixation with posterolateral fusion result in spontaneous anterior interbody fusion (which is accelerated if a disc space debridement is done).[3] Meanwhile, debridement combined with posterior instrumentation and fusion using autologous bone grafts achieves a fusion rate of 93%–96% and excellent clinical outcomes.[34,47] Interbody fusion rate in our study was observed in 89.5% within 12 months, and two patients (10.5%) showed a delayed union in the operative group. In the conservative group, spontaneous interbody fusion within a year was observed in 26.3% of cases, probably due to less osteogenic potential to induce spontaneous fusion in pyogenic spondylodiscitis than tuberculous spondylodiscitis.[5]

A study by Veeravagu *et al*.[48] shows that patients with a wound infection following spinal intervention have a more extended hospital stay, higher mortality, and higher return rates to the operation room as compared to those without surgical wound infections. Besides, these infections represent an additional cost to health care. Furthermore, Thalgott *et al*.[49] report an average additional cost of $200,000 for each of these patients. Our study shows doubling of the total cost in these procedures compared to the primary surgery, which is significant in the operative group more than the conservative group (115,000/$ 1352 vs. 80,000/$ 940 vs. 35,000/$ 416).

CONCLUSIONS

Early diagnosis and appropriate prompt management can eradicate the infection and limit damage to local tissues, including the neural elements. Even though the results were similar for both the treatment groups in terms of infection control, early surgical intervention is recommended, evidenced by shortened hospital stays, shorter duration of antibiotic therapy, higher infection clearance, and a bigger chance of preventing kyphosis. After all, this provides better functional outcomes and improved quality of life, evidenced by the resolution of pain and returning to daily activities.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Tali ET, Gültekin S. Spinal infections. Eur Radiol 2005;15:599-607.
2. Turnbull F. Postoperative inflammatory disease of lumbar discs. J Neurosurg 1953;10:469-73.
3. Basu S, Ghosh JD, Malik FH, Tikoo A. Postoperative discitis following single-level lumbar discectomy: Our experience of 17 cases. Indian J Orthop 2012;46:427-33.
4. Onik G. Automated percutaneous biopsy in the diagnosis and treatment of infectious discitis. Neurosurg Clin North Am 1996;7:145-50.
5. Moon MS, Kim SS, Lee BJ, Moon JL, Sihn JC, Moon SI. Pyogenic discitis following discectomy. J Orthopaed Surg 2012;20:11-7.
6. Chen SH, Chen WJ, Wu MH, Liao JC, Fu CJ. Postoperative infection in patients undergoing posterior lumbosacral spinal surgery: A pictorial guide for diagnosis and early treatment. Clin Spine Surg 2018;31:225-38.
7. Osti OL, Fraser RD, Vernon-Roberts B. Discitis after discography. The role of prophylactic antibiotics. J Bone Joint Surg Br 1990;72:271-4.
8. Rawlings CE 3rd, Wilkins RH, Gallis HA, Goldner JL, Francis R. Postoperative intervertebral disc space infection. Neurosurgery 1983;13:371-6.
9. Mylona E, Samarkos M, Kakalou E, Fanourgiakis P, Skoutelis A. Pyogenic vertebral osteomyelitis: A systematic review of clinical characteristics. Semin Arthritis Rheum 2009;39:10-7.
10. Jain M, Sahu RN, Gantaguru A, Das SS, Tripathy SK, Pattnaik A. Postoperative lumbar pyogenic spondylodiscitis: An institutional review. J Neurosci Rural Pract 2019;10:511-8.
11. Gouliouris T, Aliyu S, Brown N. Spondylodiscitis: Update on diagnosis and management. J Antimicrobial Chemother 2010;65 Suppl 3:Iii11-24.
12. Silber JS, Anderson G, Vaccaro AR, Anderson PA, McCormick P. Management of postprocedural discitis. Spine 2002;2:279-87.
13. Luzzati R, Giacomazzi D, Danzi MC, Tacconi L, Concia E, Vento S. Diagnosis, management and outcome of clinically- suspected spinal infection. J Infect 2009;58:259-65.
14. Hadjipavlou AG, Korovessis PG, Nakavelakis KN. Spine infections: Medical versus surgical treatment options. In: Vaccaro AR, Eck JC, editors. Controversies in Spine Surgery: Best Evidence Recommendations. 1st ed., Sec. 5. New York, Stuttgart: Thieme Publishers; 2010. p. 250-60.
15. Rohde V, Meyer B, Schaller C, Hassler WE. Spondylodiscitis after lumbar discectomy. Incidence and a proposal for prophylaxis. Spine (Phila Pa 1976) 1998;23:615-20.
16. Bavinzski G, Schoeggl A, Trattnig S, Standhardt H, Dietrich W, Reddy M, *et al*. Microsurgical management of postoperative disc space infection. Neurosurg Rev 2003;26:102-7.
17. Lee JK, Amorosa L, Cho SK, Weidenbaum M, Kim Y. Recurrent lumbar disk herniation. J Am Acad Orthop Surg 2010;18:327-37.
18. Lin E, Escott E, Garg K, Bleicher A. Practical Differential Diagnosis for CT and MRI. New York: Thieme Medical Publishers Inc.; 2008.
19. Chaudhary SB, Vives MJ, Basra SK, Reiter MF. Postoperative spinal wound infections and postprocedural diskitis. J Spinal Cord Med 2007;30:441-51.
20. Willems PC, Jacobs W, Duinkerke ES, De Kleuver M. Lumbar discography: Should we use prophylactic antibiotics? A study of 435 consecutive discograms and a systematic review of the literature. J Spinal Disord Tech 2004;17:243-7.
21. Sharma SK, Jones JO, Zeballos PP, Irwin SA, Martin TW. The prevention of discitis during discography. Spine J 2009;9:936-43.
22. Puranen J, Mäkelä J, Lähde S. Postoperative intervertebral discitis. Acta Orthop Scand 1984;55:461-5.
23. Santhanam R, Lakshmi K. A retrospective analysis of the management of postoperative discitis: A single institutional experience. Asian Spine J 2015;9:559-64.
24. McHenry MC, Easley KA, Locker GA. Vertebral osteomyelitis: Long-term outcome for 253 patients from 7 Cleveland-area hospitals. Clin Infect Dis 2002;34:1342-50.
25. Safran O, Rand N, Kaplan L, Sagiv S, Floman Y. Sequential or simultaneous, same-day anterior decompression and posterior stabilization in the management of vertebral osteomyelitis of the lumbar spine. Spine (Phila Pa 1976) 1998;23:1885-90.
26. Sapico FL, Montgomerie JZ. Pyogenic vertebral osteomyelitis: Report of nine cases and review of the literature. Rev Infect Dis 1979;1:754-76.
27. Hsieh PC, Wienecke RJ, O'Shaughnessy BA, Koski TR, Ondra SL. Surgical strategies for vertebral osteomyelitis and epidural abscess. Neurosurg Focus 2004;17:E4.
28. Korovessis P, Repantis T, Iliopoulos P, Hadjipavlou A. Beneficial influence of titanium mesh cage on infection healing and spinal reconstruction in hematogenous septic spondylitis: A retrospective analysis of surgical outcome of twenty-five consecutive cases and review of literature. Spine (Phila Pa 1976) 2008;33:E759-67.
29. Chen WH, Jiang LS, Dai LY. Surgical treatment of pyogenic vertebral osteomyelitis with spinal instrumentation. Eur Spine J 2007;16:1307-16.
30. Frank AM, Trappe AE. The role of magnetic resonance imaging (MRI) in the diagnosis of spondylodiscitis. Neurosurg Rev 1990;13:279-83.
31. Levi AD, Dickman CA, Sonntag VK. Management of postoperative infections after spinal instrumentation. J Neurosurg 1997;86:975-80.
32. Mann S, Schütze M, Sola S, Piek J. Nonspecific pyogenic spondylodiscitis: Clinical manifestations, surgical treatment, and outcome in 24 patients. Neurosurg Focus 2004;17:E3.
33. Collert S. Osteomylelitis of the spine. Acta Orthop Scand 1977;48:283-90.
34. Fang D, Cheung KM, Dos Remedios ID, Lee YK, Leong JC. Pyogenic vertebral osteomyelitis: Treatment by anterior spinal debridement and fusion. J Spinal Disord 1994;7:173-80.

35. Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. Hematogenous pyogenic spinal infections and their surgical management. Spine (Phila Pa 1976) 2000;25:1668-79.
36. Przybylski GJ, Sharan AD. Single-stage autogenous bone grafting and internal fixation in the surgical management of pyogenic discitis and vertebral osteomyelitis. J Neurosurg 2001;94:1-7.
37. Yousef AH, El-Sherif AM, Barakat YA. Role of surgery in management of discitis. Egypt J Hosp Med 2018;72:5666-72.
38. Tsai TT, Yang SC, Niu CC, Lai PL, Lee MH, Chen LH, *et al*. Early surgery with antibiotics treatment had better clinical outcomes than antibiotics treatment alone in patients with pyogenic spondylodiscitis: A retrospective cohort study. BMC Musculoskelet Disord 2017;18:175.
39. Chang CW, Tsai TT, Niu CC, Fu TS, Lai PL, Chen LH, *et al*. Transforaminal interbody debridement and fusion to manage post discectomy discitis in lumbar spine. World Neurosurg 2019;121:755-60.
40. Das S, Mahmood E, Alam MJ, Rashid M, Mitra PK. Management of postoperative discitis: A study on 20 cases of prolapsed lumbar intervertebral disc (PLID) operation in a tertiary level hospital in Bangladesh. J Dhaka Med Coll 2014;23:186-90.
41. Sheha AF. Surgical management of post discectomy spondylodiscitis with transforaminal lumbar interbody fusion (TLIF) and posterior instrumentation. Life Sci J 2011;84:1-8.
42. Hamdan TA. Postoperative disc space infection after discectomy: A report on thirty-five patients. Int Orthop 2012;36:445-50.
43. Rayes M, Colen CB, Bahgat DA, Higashida T, Guthikonda M, Rengachary S, *et al*. Safety of instrumentation in patients with spinal infection. J Neurosurg Spine 2010;12:647-59.
44. Lee MC, Wang MY, Fessler RG, Liauw J, Kim DH. Instrumentation in patients with spinal infection. Neurosurg Focus 2004;17:E7.
45. Hadjipavlou AG, Katonis PK, Gaitanis IN, Muffoletto AJ, Tzermiadianos MN, Crow W. Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis. Eur Spine J 2004;13:707-13.
46. Guerado E, Cerván AM. Surgical treatment of spondylodiscitis. An update. Int Orthop 2012;36:413-20.
47. Endres S, Wilke A. Posterior interbody grafting and instrumentation for spondylodiscitis. J Orthop Surg (Hong Kong) 2012;20:1-6.
48. Veeravagu A, Patil CG, Lad SP, Boakye M. Risk factors for postoperative spinal wound infections after spinal decompression and fusion surgeries. Spine (Phila Pa 1976) 2009;34:1869-72.
49. Thalgott JS, Cotler HB, Sasso RC, LaRocca H, Gardner V. Postoperative infections in spinal implants. Classification and analysis—a multicenter study. Spine (Phila Pa 1976) 1991;16:981-4.