Clinical Article

Is Titanium Mesh Cage Safe in Surgical Management of Pyogenic Spondylitis?

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Objective : To report our experience with pyogenic spondylitis treated with anterior radical debridement and insertion of a titanium mesh cage and to demonstrate the effectiveness and safety of the use of a titanium mesh cage in the surgical management of pyogenic spondylitis.

Methods : We retrospectively analyzed the clinical characteristics of 19 patients who underwent surgical treatment in our department between January 2004 and December 2008. The average follow-up period was 11.16 months (range, 6-64 months). We evaluated risk factors, cultured organisms, lab data, clinical outcomes, and radiographic results. Surgical techniques for patients with pyogenic spondylitis were anterior radical debridement and reconstruction with titanium mesh cage insertion and screw fixation. All patients received intravenous antibiotics for at least 6 weeks postoperatively, and some patients received oral antibiotics.

Results : The infections resolved in all of the patients as noted by normalization of their erythrocyte sedimentation rates and C-reactive protein levels. The mean pain score on a Visual Analog Scale was 7.8 (range, 4-10) before surgery and 2.4 (range, 1-5) after surgery. The Frankel grade was improved by one grade in seven patients. After surgery, the average difference of the angle was improved about 6.96° in all patients. At the last follow-up, the mean loss of correction was 4.86°.

Conclusion : Anterior radical debridement followed by the placement of instrumentation with a titanium mesh cage may be a safe and effective treatment for selected patients with pyogenic spondylitis. This surgical therapy does not lead to recurrent pyogenic spondylitis.

Key Words : Pyogenic spondylitis · Corpectomy · Titanium.

INTRODUCTION

Osteomyelitis of the spine comprises approximately 1 to 7% of all osseous infections[1,32], but it can be associated with devastating morbidity and mortality due to delayed diagnosis, misdiagnosis, or inadequate treatment[20].

The majority of patients with pyogenic spondylitis can be treated nonsurgically with external immobilization and culture-specific antibiotics for a minimum of 4 to 6 weeks[20,28,31]. However, when pyogenic spondylitis is complicated by neurologic impairment, abscess formation, recurrence of infection, severe pain, segmental instability, local kyphosis, or a combination of these factors and the absence of clinical improvement, surgical treatment should be performed to control the disease successfully[5,24].

The aim of treatment is to control the infection and to prevent neurological complications and progression of vertebral defor-

mity. We reviewed our experience with performing corpectomy which involves nearly radical removal of the infected vertebral body and debridement of necrotic tissues, and fusion with a titanium mesh cage in patients with pyogenic spondylitis, and we demonstrated the effectiveness and safeness of titanium mesh cage in the surgical management of pyogenic spondylitis.

MATERIALS AND METHODS

From January 2004 to December 2008, 28 patients who had been diagnosed with pyogenic spondylitis were surgically treated with titanium mesh at a single institution. Among patients with pyogenic spondylitis, patients who were treated with only antibiotics after percutaneous needle biopsy were excluded from this study. There were 19 patients (9 men and 10 women) who were available for follow-up evaluation and were included in this study. The mean age of patients at the time of surgery was 55.74 years (range, 6-82 years). The average follow-up period was 11.16 months (range, 6-64 months).

The diagnosis of pyogenic spondylitis was based on clinical presentation; imaging findings, including findings on plain X-ray, computed tomography, and magnetic resonance imaging; and hematologic examinations, including blood cell count anal-

ysis, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR). We reviewed the following data for all of the patients : age, sex, level of spondylitis, risk factors, serum albumin level, tissue culture results, surgical approach, neurological status, laboratory studies, clinical outcomes, recurrence, mortality, and morbidity.

In this study, neurological status was graded according to the Frankel classification. Pain was evaluated using the Visual Analog Scale (VAS). The radiographic analysis included the preoperative, immediate postoperative, and last follow-up assessment of the sagittal profile (kyphotic angle) as measured by the angle between the endplate above and below the infected vertebrae. For statistical comparisons, we performed the one-sample t-test and the paired t-test using SPSS 12.0 for Windows. In all cases, *p* values less than 0.05 were considered statistically significant.

Surgical technique

All patients were positioned in the lateral decubitus position. The skin incision began posteriorly near the midline and was made in an oblique fashion. We resected all infected and necrotic tissues with a radical debridement. Intraoperative tissue culture and smear were performed at the resected vertebral body. Then a tailored titanium mesh cage, which was filled with allobone graft with or without rib graft, was inserted in the corpectomy site to enhance stability and produce sufficient lordosis or kyphosis. Anterior instrumentation was performed in thoracic, thoracolumbar, and upper lumbar spine cases. Staged posterior instrumentation, which was followed by anterior de-

bridement, was applied in 9 patients who had involvement of lower lumbar or multiple vertebral bodies within 2 weeks after initial surgery.

All patients were empirically placed on intravenous antibiotic treatment for 6 weeks followed by at least 2 weeks of oral administration or up to the time when ESR and CRP returned to normal limits. Mobilization of the patient started within 3 to 5 days postoperatively with the help of external supports to minimize postoperative complications.

RESULTS (Table 1)

Sex/Age

The study included 9 men (47%) and 10 women (53%), and the average age was 55.74 years, ranging from 6 to 82 years.

Predisposing factors for pyogenic spondylitis

Many patients with pyogenic spondylitis had diabetes mellitus (8 cases) and other infections (7 cases), such as pneumonia (1 case), meningitis (1 case), acute pyelonephritis (2 cases), chronic osteomyelitis of another site (2 cases), and septic thrombophlebitis (1 case). Other general conditions, such as end-stage renal disease (3 cases) and adrenal insufficiency (1 case), were diagnosed preoperatively.

Bacteriology

Tissue culture data, which were obtained during the operative procedures, were collected in all 19 patients. However, in 4 pa-

Table 1. Summary of patients data

Age/Sex	Levels	Predisposing factors	Causative organism	Approach	ESR (mm/hr)	CRP (mg/L)
69/M	L3, 4	Chronic osteomyelitis	No growth	Retroperitoneal	40	7.9
63/F	L4, 5	DM	Steptococcus group	Combined	67	15.2
40/F	L4, 5, EA	DM, pneumonia, meningitis	K. pneumonia	Combined	37	104
33/M	L3, 4, 5, EA	Pneumonia, septic thrombophlebitis	K. pneumonia	Combined	45	78
63/F	L3	DM, Adrenal insufficiency	MRSA	Retroperitoneal	4	26.3
63/F	T12, L1, 2, EA	Subphrenic abscess, acupuncture	No growth	Thoracoabdominal	37	134
63/M	L4, 5, EA	Systemic sclerosis, acupuncture	Pseudomonas putiba	Combined	27	20.1
46/F	L3, 4	DM, ESRD	S. epidermidis	Retroperitoneal	102	29.6
42/M	T10, 11	Deep vein thrombosis	MRSA	Transthoracic	113	108
29/F	T8, 9, 10, 11	Deep vein thrombosis	No growth	Combined	64	17.7
65/F	L4, 5	ESRD	CNS	Combined	81	3.4
70/M	L4, 5, EA	DM, discitis, L4/5 PLIF & PSF	No growth	Combined	58	79.6
82/M	T9, 10, EA	DM, ARF, chronic osteomyelitis	MRSA	Transthoracic	91	46.4
6/M	C5, 6, EA	APN, ARF, peritonitis	MRSA	Anterior cervical	120	60
72/F	L2, 3, 4, 5	DM, Psoas abscess	E.coli	Combined	73	45.5
49/M	T12, L1, L2	Acute cholecystitis, psoas abscess, T11, L1, L2 PSF & posterolateral fusion	MRSA	Thoracoabdominal	70	79
67/M	L2, 3	Psoas abscess	MRSA	Thoracoabdominal	88	28.3
72/F	L3, 4	Deep vein thrombosis, APN	MRSA	Combined	34	28.5
65/F	L2, 3	DM, HTN, ESRD	K. pneumonia	Thoracoabdominal	66	105

ESR : erythrocyte sedimentation rate, CRP : C-reactive protein, EA : epidural abscess, DM : diabetes mellitus, ESRD : end stage renal disease, ARF : acute renal failure, APN : Acute pyelonephritis, HTN : hypertension, K. pneumonia : Klebsiella pneumonia, MRSA : Methicillin-resistant Staphylococcus aureus, S. epidermidis : Staphylococcus epidermidis, CNS : coagulase-negative staphylococcus, E.coli : Escherichia coli, PLIF : posterior lumbar interbody fusion, PSF : pedicle screw fixation

tients there were no bacterial isolates. Among the 15 patients with culture data, *Staphylococcus aureus* was the most common strain in pyogenic spondylitis (7 cases), followed by *Klebsiela pneumonia* (3 cases). *Streptococcus*, *Staphylococcus epidermidis*, Coagulase-Negative *Staphylococcus*, *Escherichia coli*, and *Pseudomonas putiba* were also isolated in each of five patients.

Distribution and number of spinal infections

The lumbar spine was the most common site of pyogenic spondylitis (13 cases), followed by the thoracic spine (3 cases) (Fig. 1). There were two cases that involved the thoracolumbar spine and one case that involved the cervical spine. The number of infected vertebral bodies varied from one to four. Two levels of vertebral body infection were identified in 13 patients, followed by three infection sites in three patients, four infection site in two patients, and one infection sites in one patient.

Laboratory findings

Blood sampling was performed preoperatively and postoperatively to evaluate for changes of the WBC count, ESR, and CRP level. The preoperative WBC count was elevated in 10 patients (53%). The CRP level was elevated in 15 patients. The ESR was elevated in most patients (18 cases). The WBC counts averaged 10,332/μL (range, 3,900-22,360) before surgery and 7,694/μL (range, 4,110-11,500) at discharge. The CRP was 53.48 mg/L (range, 3.4-134) before surgery and 17.76 mg/L (range, 5-41.9) at discharge. The ESR was 64.05 mm/hr (range 4-120) before surgery and 31.78 mm/hr (range, 2-87) at discharge. Most patients had a decrease in WBC count, ESR, and CRP. The preoperative mean value of serum albumin, which was used as a nutritional marker, was 3.06 (range, 2-4).

Approach

Among the 19 surgically-treated patients, 10 patients were managed by the anterior surgical approach only, and 9 patients were managed with the addition of the posterior approach. We used a titanium mesh cage for the reconstruction of the anterior column. The surgical approach was determined by location and number of lesions. A thoracoabdominal approach was performed in four cases, a retroperitoneal approach was performed in three cases, a transthoracic approach was performed in two cases, an anterior cervical approach was performed in one case, and the others were performed via combined approach (Fig. 2).

Clinical outcomes

The mean VAS score was 7.8 (range, 4-10) before surgery and 2.4 (range, 1-5) after surgery. Prior to surgery, two patients were classified as Frankel type A, two as Frankel type C, and 15 as Frankel type D. After surgery, the neurological status changed in seven patients and improved by 1 Frankel grade. One patient, who had a preoperative diagnosis of diabetes mellitus and adrenal insufficiency, died due to postoperative acute respiratory distress syndrome. There was no recurrence of infection in patients who received nearly radical debridement of the infected tissue followed by reconstruction using a titanium mesh cage.

Radiographic results

Radiographically, there were no instrumentation failures, such as expulsion or migration of any implanted titanium mesh cage or pullout of the transpedicular screws. The average segmental kyphosis, or loss of lordosis, was 20.07 degrees (range 4.5° to 35.7°) before surgery. After surgery, the average difference of the angle improved about 6.96° in all patients. At the last follow-up,

Fig. 1. A 82-year-old male with a supramediastinitis, in whom the blood culture showed bacteremia with Methicillin-resistant Staphylococcus aureus. Pyogenic spondylitis at the T9, 10 levels on enhanced magnetic resonance imaging (A and B). Reconstruction using titanium mesh cage and allograft and stability with the anterior approach on plain radiographs (C and D).

Fig. 2. A 72-year-old female with an acute cholecystitis, in whom the blood culture showed bacteremia with E.coli. A lumbar spine enhanced magnetic resonance imaging was taken due to back pain. Pyogenic spondylitis was seen on L2, 3, 4, 5 levels (A and B). A surgical intervention was done following the failure of antibiotics (C and D).

there were some loss of the surgical correction compared to immediately after the operation; the mean loss of correction was 4.86° (*p*=0.031).

DISCUSSION

Pyogenic spondylitis has traditionally been of little concern to neurosurgeons due to its relatively infrequent occurrence. However, the incidence of spinal infection in general has increased over the past two decades. The reasons for this increase include the growth of the elderly population, many of whom have multiple chronic medical problems, and an overall increase in the number of individuals of any age with chronic debilitating illness, such as diabetes mellitus, intravenous drug use, alcoholism, malignancy, chronic renal failure/dialysis, and degenerative spinal disorders. Other sites of infection, such as soft tissue infection, urosepsis, pulmonary infection, dental infection, endocarditis, and septic arthritis, can contribute to spinal infections. In this population, spinal procedures also have likely contributed to the increased rate of spinal infection[4,12,16,22,25,26,29,31]. Preoperative nutritional status is strongly associated with postoperative complications. Nakamura et al.[21] have reported that the preoperative albumin level was associated with the postoperative CRP level and that a patient's preoperative nutritional status affects postoperative immunity and the inflammatory response. In our study, patients who developed pyogenic spondylitis exhibited lower serum albumin levels (average 3.06, range 2-4) (*p*=0.019).

The most commonly isolated organism in this study was *Staphylococcus aureus* (36.84%). This result is lower than most reports in the literature, with *Staphylococcus aureus* accounting for 40% to 80% of the isolated organisms in other reports[10,15].

This difference could be explained by the fact that negative cultures were obtained 21.05% of the time in this study, which is consistent with the rate of 20-30% reported by other studies[7,13,35]. Three explanations have been given for this result : antibiotics before surgery[9], and the natural healing of intervertebral disc infection as postulated by Fraser[8]. According to Fraser's theory[8], vascular granulation tissue from the vertebral subchondral plate invades and resorbs the infected disc space, enabling the infected region to heal spontaneously after approximately 6 weeks, thus leading to negative cultures[18]. In our study, most patients had been treated with antibiotics before transfer to our hospital, so the proportion of negative cultures was high like other studies.

In most patients, intravenous antibiotic drugs should be administered for 6 to 8 weeks, and this should be followed by oral antibiotics until the infection resolves[2,10]. Insufficient antibiotic administration, such as a duration less than 4 weeks, is associated with a 25% relapse rate[6,30,31]. The criteria for discontinuation of antibiotic therapy were the following : 1) decrease of spinal pain with disappearance of the inflammatory pattern; 2) normal body temperature; 3) normal CRP and/or ESR levels; and 4) stabilization or improvement in the disk and vertebral abnormalities on plain radiographs[17].

Major indications for surgery include the following : 1) to obtain a bacteriologic diagnosis when closed biopsy is deemed unsafe or when multiple adequately performed closed biopsies have been negative, blood cultures are negative, and no other source of infection is apparent; 2) when a significant abscess is present causing unremitting fever and systemic signs of sepsis; 3) in cases refractory to adequate nonoperative management in which the ESR remains markedly elevated or there is persistence of significant spinal pain; 4) in the presence of a neuro-

logic deficit due to spinal cord compression; and 5) in cases associated with significant vertebral body destruction and spinal deformity, especially in the cervical spine[19].

The principles of surgical treatment in spinal osteomyelitis include removal of infected tissue, restoration of neurological function, restoration of sagittal and coronal plane alignment, and spinal stabilization to prevent further deformity, pain, or neurological deficit[34]. Generally, most osteomyelitic infections and deformities of the spine are situated in the anterior and middle column, and surgical debridement with or without internal fixation is usually first performed via an anterior approach[3,7,32]. The complications after surgical treatment without instrumentation are loss of correction, ranging from 3° to 12°; olisthesis[6]; pseudarthrosis; and spinal stenosis[14].

The use of instrumentation in the setting of a spinal infection has always been controversial because of the concern for secondary infection. Although the use of both allografts and autografts has been accepted as safe, demonstrations of the effectiveness of titanium mesh cage have been speculative, based on several retrospective reviews[11,27]. Pascual et al.[23] compared stainless steel and titanium alloy and showed that colonization and persistence of bacteria on stainless steel devices occurs more frequently than on titanium devices. Sheehan et al.[33] showed that *Staphylococcus epidermidis* demonstrated lower ability to adhere to metals, and biofilms adhere in greater numbers to stainless steel than titanium. The presence of the mesh cage anteriorly at the site of spondylitis had a positive influence on the course of infection healing because it provided additional stabilization to the affected segment, maintaining a sufficient sagittal profile.

The reason for using a titanium mesh cage was that autologous bone grafts have limitations in cases with extensive bone loss and may result in donor site morbidity. In addition, autologous bone grafts are of insufficient length when we perform multilevel corpectomy. Allofibular bone grafts have insufficient contact surface between the vertebral body and grafts. The titanium mesh cage has advantages compared with other materials, which include alterability of length, sufficient contact surface, and a lack of donor site morbidity.

According to our study, average loss of correction between the measurement taken immediate post surgery and the last follow-up was 4.86°. The titanium mesh cage is harder than vertebral bodies, which are often osteoporotic or have low bone material quality. Therefore, the titanium mesh cage can induce loss of correction. We thought posterior instrumentation could reduce the loss of correction that was induced by the titanium mesh cage.

In our study, all pyogenic spondylitis cases that were treated with radical debridement of infectious tissues and titanium mesh cage insertion showed no recurrence of infection. Patients showed definite improvement; they were able to ambulate within 5 days after surgery with relieved pain, and plain X-ray showed improvement of their kyphosis and osseous union. These patients had an early return to their activities of daily living.

CONCLUSION

Although this is a limited series, we found that an anterior radical debridement of infected tissue followed by reconstruction with a titanium mesh cage may be a safe and effective surgical treatment for selected patients with pyogenic spondylitis. After surgery, additional medical treatment with effective antibiotic agents for an appropriate duration is also important in improving the clinical outcome and reduces the recurrence of infection. However, further studies that incorporate long term follow-up and a larger patient population are needed to confirm our findings.

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