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Use of structural allografts in spinal osteomyelitis: a review of 47 cases

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Object. The use of structural allografts in spinal osteomyelitis remains controversial because of the perceived risk of persistent infection related to a devitalized graft and spinal hardware. The authors have identified 47 patients over the last 3.5 years who underwent a surgical decompression and stabilization procedure in which fresh-frozen allografts were used after aggressive removal of infected and devitalized tissue. The patients subsequently underwent 6 weeks of postoperative antibiotic therapy (12 months for those with tuberculosis [TB]).

Methods. Follow-up data included results of serial clinical examinations, radiography, laboratory analysis (erythrocyte sedimentation rate and white blood cell count), and clinical outcome questionnaires. Of the original 47 patients (14 women and 33 men, aged 14–83 years), 39 were available for follow up. The average follow-up period at the time this article was submitted was 17 $\pm$ 9 months (median 14 months, range 6–45 months). In the majority of cases (57%), a *Staphylococcus* species was the infectious organism. Predisposing risk factors included intravenous drug abuse (IVDA), previous surgery, diabetes, TB, and concurrent infections. During the follow-up period only two patients suffered recurrent infection at a contiguous level; both had a history of IVDA and one also had a chronic excoriating skin condition. No other recurrent infections have been identified, and no patient has required reoperation for persistent infection or allograft/hardware failure.

Conclusions. It is the authors' opinion that the use of structural allografts in combination with aggressive tissue debridement and adjuvant antibiotic therapy provide a safe and effective therapy in cases of spinal osteomyelitis requiring surgery.

KEY WORDS • spine • osteomyelitis • allograft

SPINAL osteomyelitis is a complex and difficult problem to manage. Patients frequently have coexisting medical conditions that complicate their treatment and limit their ability to fight infection. Additionally, because the initial presentation can be subtle, a delayed diagnosis is possible. The mainstay of medical management is specific microbial diagnosis, targeted antibiotic treatment, and immobilization. However, despite the effectiveness of modern antibiotics in the nonsurgical treatment of spinal osteomyelitis,[2,6,17] cases involving persistent infection or neurological compromise often require surgical intervention.

In cases of gross spinal deformity or instability and in those requiring aggressive removal of infected and devitalized tissue, the use of a structural graft and spinal hardware may be required. Surgeons are particularly concerned about the risk of introducing nonliving material into an infected tissue bed. All implants are associated with the potential risk of harboring persistent infection and possible construct failure. Traditional autologous structural materials include iliac crest, rib, or fibula. However, the extent of the defect requiring reconstruction often exceeds the safe limits of the autologous tissue that can be harvested.[7,13] Procedures in which autograft alternatives such as rib or fibula (with or without vascularized pedicle) are used also add increased operative time, are more difficult to place, and are associated with greater morbidity.[24,26] Autologous grafts may also have a limited biomechanical capacity to tolerate physiological loads.[18,25] The authors of several recent series report using allograft in selected patients with spinal osteomyelitis.[5,22] Additionally, Govender and Parbhoo[8] have recently reported using anterior allograft to correct a gibbus deformity in young children with Pott's disease.

During the past 4 years, we have used structural allografts exclusively in the reconstruction of the anterior spinal column in patients requiring surgery for osteomyelitis. Our surgery-related principles dictate that we

Abbreviations used in this paper: AIDS = acquired immune deficiency syndrome; CT = computerized tomography; ESR = erythrocyte sedimentation rate; IV = intravenous; IVDA = IV drug abuse; MR = magnetic resonance; PFGE = pulse field gel electrophoresis; TB = tuberculosis.

achieve complete debridement of all necrotic and infected bone and soft tissue, as well as stable reconstruction with structural grafts and rigid fixation devices. We believe this approach in combination with organism-specific antibiotic treatment is safe and effective. In this report we describe our experience.

Clinical Material and Methods

Study Inclusion Criteria

Data obtained in all patients who underwent placement of structural allografts for osteomyelitis in the University of Washington Medical Center from April 1995 to August 1998 were retrospectively reviewed. There were 33 males and 14 females, aged 14 to 83 years. To ensure a complete list of patients, operative notes were checked against a list of all patients who received allografts (provided by our allograft service). Inclusion criteria required that patients have positive cultures and/or pathological evidence of osteomyelitis in cases in which preoperative antibiotic agents were administered and there was no growth by culture. Indications for surgical intervention were persistent infection despite medical management, neurological compromise, and gross spinal deformity or instability. All patients were treated by the same group of surgeons at the three hospitals within the University of Washington system.

Preoperative Assessment

All patients routinely provided a detailed history and underwent physical examination focused on identifying risk factors. Laboratory assessment included determining complete blood counts with differential, blood cultures, and ESR. At-risk patients underwent nutritional assessment, and perioperative nutritional supplementation was initiated when indicated. All patients underwent plain radiographyy, CT, and MR examination (if not contraindicated). In patients with a history of IVDA an echocardiogram was obtained to rule out endocarditis. Antibiotic agents were withheld preoperatively until a specific organism could be identified by blood culture, CT-guided biopsy sampling, or intraoperative inspection.

Surgical Procedures

In preoperative planning we took into account the extent of anterior and posterior involvement and the number of involved vertebral levels before determining the best combination of approaches to provide the most stable construct. Additionally, intraoperative electromyography and somatosensory evoked potential monitoring were performed.

Anterior cervical lesions were approached via a standard anterior cervical approach. Corpectomies and discectomies were performed to remove all infected/devitalized tissue. Fibula allografts were used in addition to anterior cervical plate fixation. When indicated, posterior fusion was undertaken using lateral mass plates.

Lesions located in the thoracic region were approached via staged anterior–posterior procedures. The anterior approach was undertaken through a thoracotomy, and corpectomy/discectomy, tibial strut graft placement, and buttress plating were performed. Posterior stabilization was performed on a delayed basis and consisted of titanium pedicle screw–rod segmental fixation.

Lumbar–sacral lesions were approached retroperitoneally via either a flank or paramedian incision, and decompression, tibial allograft placement, buttress plating, and posterior pedicle screw–rod segmental fixation (similar to the thoracic patient group) were performed. Four patients were treated exclusively via an anterior procedure in which a strut graft and an anterior thoracolumbar locking plate construct were placed.

All patients in whom a cervical lesion was resected were placed in a Philadelphia collar or Minerva brace for 8 to 12 weeks postoperatively. Patients in whom a thoracolumbar lesion was resected were placed in a rigid external orthosis for 12 weeks postoperatively.

Allograft Material

Fresh-frozen allografts (tibia or fibula) were obtained from the Northwest Tissue Center (Seattle, WA). The allografts were subsequently thawed in normal saline prior to implantation.

Postoperative Care

Patients with no stable residence or who were at high risk for noncompliance were admitted to skilled nursing facilities to receive IV antibiotics and aggressive nutritional support. Patients received 6 weeks of IV antibiotic treatment except those with TB who underwent multidrug therapy for 12 months postoperatively. Additionally, all patients were treated with an external orthosis for 8 to 12 weeks. Ideal follow up included return visits to the clinic at 1, 3, 6, 12, and 24 months postoperatively (and at 1- to 2-year intervals thereafter), at which time the patient underwent serial clinical examination and radiographic study, completed a functional spine outcome form, and ESRs were determined. Because of our large referral area, some follow-up care was provided by referring physicians. For patients unable or unwilling to undergo follow up, outcome questionnaires were obtained and/or phone interviews were conducted. The immediate postoperative radiological studies were compared with the most recent studies to assess hardware and allograft alignment, integrity, and incorporation.

Results

Table 1 provides a summary of the patient data. Of the original 47 patients (14 males and 33 females, aged 14–83 years) 39 (83%) were available for at least 6 months of follow up. There were seven deaths: the patient in Case 9 returned to independent living but died of pancreatic cancer 12 months postoperatively; the patient in Case 12 regained ambulatory status with the assistance of a walker but died of colon cancer 8 months postoperatively; the patient in Case 21 died of sepsis 3 weeks postoperatively; the patient in Case 27 died of a myocardial infarction 2 weeks postoperatively; the patient in Case 31 died of AIDS complications 18 months postoperatively; the patient in Case 41 died of endocarditis-related complications 4 months postoperatively; and the patient in Case 46 died in a fall 3 months postoperatively. Four patients (Cases 19, 26, 33, and 34) were lost to follow up after 5, 3, 5, and 5 months postoperatively, respectively.

TABLE 1

*Summary of data in 47 patients with osteomyelitis in whom allografts were placed**

Case No.	Age (yrs), Sex	Predisposing Factor	Infectious Organism	Level	Allograft	Op	Follow Up (mos)	Outcome
1	29, M	prev op/infection	GPC, MRSA from nares	L4–5	tibia	L4–5 corp, AP fusion	25	returned to work, neuro intact
2	60, F	retropharyngeal abscess	*S. aureus*	C4–5	fibula	C4–5 corp, AP fusion	7	improved but persistent UE/neck pain
3	42, M	IVDA/hepatitis	*S. aureus*	C6–7, L4–5	fibula/tibia	C6–7, L4–5 corp, AP fusion	6	neuro intact
4	59, M	DM	*S. epidermidis*	L-5	tibia	L-5 corp, AP fusion	11	neuro intact, minimal back pain
5	47, M	prev injury	*S. aureus*	T10–11	tibia	T10–11 corp, AP fusion	31	incomplete paraplegia, skilled nursing facility for head injury
6	46, F	IVDA	*S. aureus*	C5–6	fibula	C5–6 corp, AP fusion	34	persistent but improved quadriparesis
7	38, M	prev injury/op	*S. epidermidis*/*Enterococcus*	L2–3	tibia	L2–3 corp, AP fusion	13	mild LE pain, persistent erectile dysfunction
8	52, F	DM/RA/steroids	*E. coli*	T-11	tibia	T-11 corp, AP fusion	27	no evidence of infection, persistent back pain, neuro intact
9	83, M	prev op	*S. aureus*	L1–2	tibia	L1–2 corp, AP fusion	12	returned to independent living, died of pancreatic cancer
10	47, M	prev op	*S. aureus*	C6–7	fibula	C6–7 corp, AP fusion	25	improved paraparesis, neck/arm pain
11	68, M	prev op	*S. epidermidis*, *E. vulgaris*	L3–4	tibia	L3–4 corp, AP fusion	15	persistent but improved LE/back pain
12	82, M	DM	*Streptococcus* G	T5–6	fibula	T5–6 corp, post fusion	8	improved paraparesis/died of colon cancer
13	81, F	prev op	*S. epidermidis*	L2–3	tibia	L2–3 corp, ATLP	22	persistent low-back/leg pain
14	43, M	AS, C5–6 fracture, prev AP fus	sterile retropharyngeal abscess	C4–6	fem condyle	ant debridement, occiput–T4 post fus	25	persistent mild quadriparesis
15	45, M	prev fracture	*S. aureus*	T10–12	tibia	T10–12 corp, AP fusion	24	persistent LE paraparesis
16	44, M	DM, pancreatitis	GPC + path	L5–S1	tibia	L-5 part S-1 corp, AP fusion	20	neuro intact, persistent back pain
17	45, F	IVDA	*S. aureus*	L2–3, T12–L3, L5–S1	tibia	L2–3 corp, AP fusion; rev L1–3 corp, part L5–S1 corp, AP fusion	12	neuro intact, no evidence of recurrent infection
18	62, M	quadriplegia, UTI	*S. aureus*	L-5	fibula	L-5 corp, AP fusion	11	no recurrence of symptoms
19	42, M	IVDA	*S. aureus*	T12–L1	tibia	T12–L1 corp, ATLP	5	doing well at 5 mos but lost to FU
20	61, F	TB	TB	L1–2	tibia	L1–2 corp, AP fusion	9	neuro intact, no evidence of infection
21	55, F	DM	*S. aureus*	L3–5	tibia	L3–5 corp, ant fusion	0.75	died of sepsis in hospital
22	42, M	IVDA	*S. aureus*	T5–6	tibia	T5–6 corp, AP fusion	14	resolving paraparesis
23	39, M	fracture/IVDA	β-*Streptococcus*	T12–L2	tibia	L-1 part T-12, L-2 corp, AP fusion	10	neuro intact, mild back pain
24	49, M	prev op	*Streptococcus*	L4–5	tibia	L4–5 corp, AP fusion	7	resolving paraparesis
25	44, M	DM, epidural abscess	epidural abscess–no growth	L5–S1	tibia	part L5–S1 corp, AP fusion	30	persistent back pain, negative bone scan
26	43, F	IVDA	*S. aureus*	L5–S1	fibula	part L5–S1 corp, ant fusion	3	lost to FU
27	81, M	TB	TB	T11–12	tibia	T11–12 corp/ATLP	0.50	died of cardiac arrest while in hospital
28	47, F	IVDA, prev infection/op	*S. aureus*	L3–5	tibia	part L4–5 corp, AP fusion	14	neuro intact, persistent back pain
29	41, F	IVDA	*S. aureus*	L4–5	tibia	L4–5 corp, AP fusion	16	doing well/previous symptoms resolved
30	31, M	prev op	*S. aureus*	L5–S1	tibia	L5–S1 part corp, AP fusion	13	neuro intact except for retrograde ejaculation
31	42, M	IVDA/HIV	*S. aureus*	C3–4	fibula	C3–4 corp, AP fusion	18	no recurrent infection, died of AIDS 18 months postop
32	48, M	dermatitis/IVDA	*S. aureus*	L2–5	tibia	L4–5 corp, AP fusion; L-2 corp, rev AP fusion	45	neuro intact, no pain
33	23, M	prev gunshot wound	α-*Streptococcus*	C2–4	fibula	C3–4 corp, AP fusion	5	resolving quadriparesis, lost to FU
34	14, M	TB	TB	T11–L1	tibia	T11–L1 corp, AP fusion	5	lost to FU
35	48, M	IVDA/meningitis	*S. pneumoniae*	L5–S1	tibia	part L5–S1 corp, AP fusion	12	neuro intact persistent back pain/spasm
36	59, M	TB	TB	T9–10	tibia	T9–10 corp, AP fusion	26	doing well/minimal back pain
37	51, F	TB	TB	T7–8	tibia	T7–8 corp, AP fusion	26	doing well/minimal back pain
38	53, M	DM	*S. aureus*	T9–10	tibia	T9-10 corp, ATLP	12	resolving paraparesis

Continued →

TABLE 1
*Summary of data in 47 patients with osteomyelitis in whom allografts were placed**

Case No.	Age (yrs), Sex	Predisposing Factor	Infectious Organism	Level	Allograft	Op	Follow Up (mos)	Outcome
39	45, M	fracture/prev op	sterile retropharyngeal abscess	C5–T1	fibula	C5–T1 corp, AP fusion	15	hardware removed at 6 mos; solid fusion, no infection
40	61, M	MRSA in nares	MRSA	L5–S1	tibia	part L5–S1 corp, AP fusion	6	neuro intact, no pain
41	38, F	IVDA	*S. aureus*	L4–5	fibula	part L4–5 corp, AP fusion	4	died of complications from endocarditis
42	58, M	DM	*S. aureus*	L5–S1	tibia	L-5, part S-1 corp, AP fusion	12	neuro intact, minimal back pain
43	46, M	unknown risk	*Aspergillus*	T7–8	tibia	T7–8 part T-9 corp, AP fusion	12	improved paraparesis
44	45, M	prev gunshot wound	*Pseudomonas*	L3–4	tibia	L3–4 corp, AP fusion	19	neuro intact, minimal pain
45	52, M	prev op	*S. aureus*	C4–6	fibula	C4–6 corp, AP fusion	10	return to work, doing well
46	20, F	TB	TB	L5–S1	fibula	L5–S1 part corp, ant fusion	3	died secondary to fall
47	69, F	DM	*S. epidermidis*	L2–3	tibia	L2–3 corp, AP fusion	24	nonambulatory, bilat below-knee amputations (DM)

* ant = anterior; AP = anteroposterior; AS = ankylosing spondylitis; ATLP = anterior thoracolumbar locking plate; corp = corpectomy; DM = diabetes mellitus; fem = femoral; FU = follow up; fus = fusion; GPC = Gram-positive *Staphylococci*; LE = lower extremity; MRSA = methicillin-resistant *S. aureus*; neuro = neurologically; part = partial; post = posterior; prev = previous; RA = rheumatoid arthritis; rev = revision; TB = tuberculosis; UE = upper extremity; UTI = urinary tract infection.

Table 2 provides a summary of the identifiable risk factors. In the patient in Case 40 methicillin-resistant *S. aureus* positive cultures were obtained from his nares, but there were no other risk factors.

In Table 3 we summarize the infectious organisms and in Table 4 the affected spinal region. In 27 (57%) of the 47 cases a *Staphylococcus* species was the infectious organism. In five patients with Gram-positive *Staphylococci* identified by Gram stain and/or pathological examination, negative cultures had been found.

The average follow-up duration at the time of this submission was 17 ± 9 months (median 14 months, range 6–45 months) for the 39 patients who underwent at least 6 months of follow up. During this time period, only two (5%) of these 39 patients required reoperation for recurrent infection at a contiguous level.

Infection-Related Complications

Case 32. This 48-year-old man had a chronic excoriating skin condition and a history of IVDA. He was initially shown to have had an *S. aureus* infection involving the L4–5 vertebral bodies. He underwent L4–5 corpectomies, tibial allograft placement, and posterior instrumentation with pedicle screw fixation. Thirty-two months postoperatively he developed fever, back pain, and an elevated ESR. Osteomyelitis with destruction of the L-2 body was demonstrated on MR imaging. There was no evidence of involvement of the previous fusion site, and CT scanning demonstrated good incorporation of the graft. He subsequently underwent an L-2 corpectomy, placement of a tibial allograft, and extension of his posterior instrumentation. Exploration of the previous fusion site showed solid incorporation of the graft and no evidence of infection. He continues to do well 14 months postoperatively with a normal ESR.

Case 17. This patient was a 45-year-old woman with a long history of IVDA. She initially presented with L2–3 osteomyelitis *(S. aureus)* with progressive spinal deformity and radiculopathy. She underwent L2–3 corpectomies, tibial allograft fusion, and placement of posterior instrumentation. Postoperatively she continued to use IV drugs and was noncompliant with her brace and IV antibiotics. She also developed a flank abscess secondary to subcutaneous drug injections. Eleven months postoperatively she represented with fever, positive *S. aureus* blood cultures, subsidence of bone around the inferior pedicle screws (Fig. 1), and progressive kyphosis. Infection at L1–3 and discitis at L5–S1 were demonstrated on MR imaging. She underwent removal of her previous graft and hardware, extensive debridement, and placement of an antibiotic (vancomycin and tobramycin)–impregnated methylmethacrylate strut. She was ordered to comply with bed rest and received antibiotics for 2 weeks. She subsequently underwent surgical revision of the previous fusion: a tibial allograft was placed and posterior fusion was performed. The bacterial isolates obtained from her two infections (separated in time by 12 months) showed similar antibiotic susceptibility. They were compared by using PFGE, a technique used to trace bacterial strains,[16] and were found to be distinct isolates, suggesting reinfection instead of recrudescent infection. Additionally, the patien-

TABLE 2
Risk factors predisposing patients to infection

Factor	No. of Cases
previous op or injury	16
IVA	13
diabetes	9
TB	6
concurrent infection*	2
unknown risk factors	1

* Urinary tract infection, retropharyngeal abscess.

TABLE 3
Infectious organisms

Organism	No. of Cases
Staphylococcus	27
TB	6
Streptococcus	5
Gram-negative rods	3
Aspergillus	1
positive-Gram stain &/or pathological entity	5

t's first preoperative ESR was 49 mm/hour. It fell to a level of 9 mm/hour 3 months postoperatively and subsequently rose to 72 mm/hour with her second infection.

Case 39. This 45-year-old man required closure of a pharyngocutaneous fistula (from his original operation) by our otolaryngology service. During the course of the exposure for this procedure, the anterior fusion site and hardware were inspected. There was evidence of a solid bone fusion and no evidence of infection. Because of the fusion, the hardware was removed. The patient subsequently did well.

No other recurrent infections have been identified, and no other patient has required reoperation for persistent infection or allograft/hardware failure.

Laboratory Assessment

The average presenting ESR was 80 $\pm$ 37 mm/hour (normal $<$ 20 mm/hour). The average postoperative ESR was 19 $\pm$ 16 mm/hour. In all patients in whom available follow-up data had been obtained, the ESR was reduced postoperatively, with 67% returning completely to normal. In patients with a history of IVDA and or other underlying health problems such as diabetes mellitus, hepatitis, or pancreatitis, the ESR was less likely to return to a completely normal level, in which case the trend over time was more meaningful.

Radiological Assessment

Anteroposterior and lateral x-ray films were used to follow patients over time. These films were independently reviewed for overall alignment, graft incorporation, hardware integrity, and evidence of infection such as bone subsidence around hardware, bone erosion, or persistent lucencies at the bone–graft interfaces. Follow-up CT or MR images were obtained when abnormalities had been detected on plain x-ray films, as it is difficult to assess bone healing with plain x-ray films alone.[11] Three patients were found to have solid fusions without evidence of infection during subsequent surgical exploration. This correlated with evidence of fusion revealed on x-ray films. There were five cases with fractures or mildly displaced screws or hardware in which there was no change in overall alignment and no evidence of nonunion or persistent infection. In the patient in Case 17, one of those who experienced a reinfection, clear evidence of subsidence of the most inferior pedicle screws was demonstrated (Fig. 1).

Outcome Assessment

Clinical outcomes are summarized in Table 1. Overall, early intervention resulted in at least some improvement in neurological status in the 13 patients who presented with neurological compromise. Five patients (Cases 5, 18, 38, 39, and 41) had developed paraparesis or quadriparesis related to previous injuries, and their neurological status was unchanged postoperatively. The patient in Case 18, who suffered quadriparesis after a previous injury, returned to work postoperatively. The patients in Cases 1, 4, 29, 32, 36, 40, 42, and 45 were neurologically intact with minimal symptoms, and of this group Cases 1, 36, 40, and 45 returned to work postoperatively. The patient in Case 30 has minimal symptoms and was neurologically intact except for retrograde ejaculation.

Of the seven patients who died, one returned to independent living (Case 31) and two to assisted living (Cases 9 and 12) before dying at 12, 8, and 18 months, respectively, of cancer (Cases 9 and 12), and AIDS (Case 31). Persistent back, neck, or extremity pain was more common in patients with incompletely resolved myelopathy or cauda equina syndrome, a history of IVDA, or a history of multiple previous spinal operations before their infection. Patients with persistent pain were followed closely for evidence of nonunion or persistent infection.

Discussion

Early experience with cases of spinal TB requiring surgery showed that aggressive removal of devitalized tissue was required for eradication of the infection and subsequent healing of bone grafts.[10] This continues to be an effective strategy for both spinal TB[21] and pyogenic infections.[22] The results of numerous reports have shown the effectiveness of primary bone fusion and spinal instrumentation for spinal reconstruction in patients with osteomyelitis.[1,5,6,9,19,20,23] Collectively, the authors indicate that early reconstruction allows the patient to become mobilized early in the postoperative period and leads to an overall improved outcome. Several authors have reported the use of allografts in selected patients with osteomyelitis.[5,22] Dietze and associates[5] have emphasized the necessity of performing aggressive debridement, and they advocate an extended course of initially IV and then oral antibiotic therapy. Additionally, Govender and Parbhoo[8] have demonstrated the utility of femoral allografts in combination with placement of posterior instrumentation for the correction of gibbus in young children (average age 4.2 years) with TB.

We sought to test the hypothesis that the use of allografts in spinal osteomyelitis is a safe and effective alternative to autograft. The results of the present retrospective study

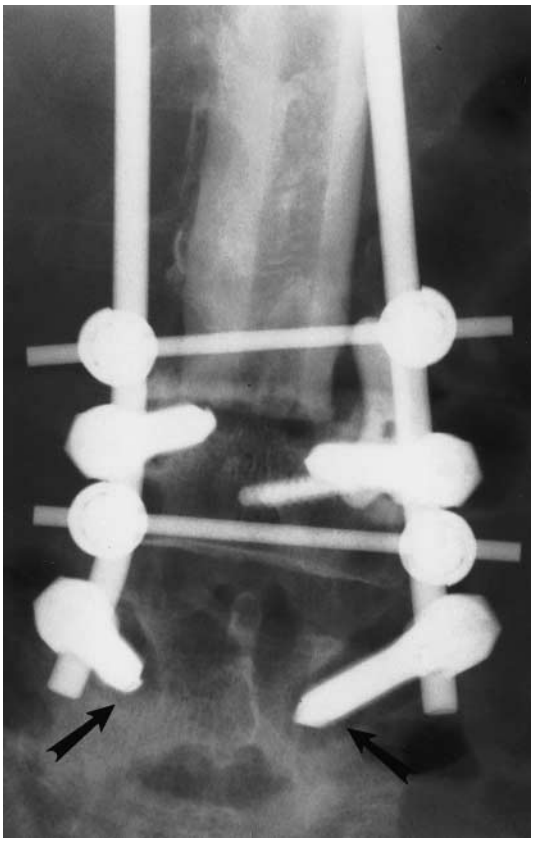

FIG. 1. Case 17. Plain x-ray film demonstrating subsidence of bone around pedicle screws with evidence of reinfection *(arrows)*.

underscore that the use of allograft is safe and effective. Moreover, bone graft incorporation is comparable with the use of allograft for noninfectious spinal reconstruction.[14,15] This method, as stated previously, also avoids the morbidity and potential biomechanical shortcomings associated with harvested autologous grafts.[4,7,13,18,24,26]

In our experience, this method is especially effective in cases in which previous operations and/or traumatic injuries are the only predisposing risk factors. With adequate treatment their ESR values will normalize. Additionally, despite the small number of patients in our series, our experience in treating patients with spinal TB has shown favorable results.

Patients with possible immune compromise and poor wound healing from diabetes or malignancy in whom the rate of wound healing has been poor, and those with high-risk lifestyles (that is, those with a history of IVDA) and concurrent chronic infections with hepatitis and for human immunodeficiency virus require a high index of suspicion for residual or recurrent infection. Unfortunately, the absolute ESR value is unlikely to normalize completely, and the reduction over time is a more meaningful trend.[3] Follow-up MR and CT studies are useful in ruling out ongoing infection. Also, ensuring adequate follow up is difficult in the IVDA population, and therefore, as stated previously, our patients with no permanent residence were often admitted to skilled nursing facilities where their antibiotic therapy continued and issues of their poor

TABLE 4

Regions of involved spine in patients with osteomyelitis

Region	No. of Cases
cervical	8
thoracic	10
lumbar	17
thoracolumbar	3
lumbosacral	8
cervicolumbar	1

nutritional status addressed.[12] Many of these patients continue to abuse IV drugs and unfortunately will be at continued risk for infections.

The two cases in our series requiring reoperation more likely reflect reinfections than recrudescent infections. In the patient in Case 32, the two infections were separated in time by almost 3 years, the patient had persistent risk factors, the infection was not at a contiguous level, and intraoperative inspection of the previous fusion showed no evidence of infection and solid incorporation. Unfortunately samples of the original isolate were not available for comparison with the second infection by PFGE. In Case 17, the patient had ongoing risk factors, the two isolates were shown to be distinct by PFGE, and her ESR normalized after the first infection. Unfortunately, because she was noncompliant at times with her postoperative care, recrudescent infection cannot be completely ruled out. Perhaps, as Dietze and associates[5] have suggested, an extended course of IV and oral antibiotics should be continued in high-risk patients.

In summary, structural allografts in combination with aggressive debridement, placement of spinal instrumentation, and concurrent antibiotic therapy provide a safe and effective therapy for spinal osteomyelitis requiring surgery. The morbidity associated with a second operative site is avoided, and the fusion rates appear to be comparable with those achieved when allografts are used in noninfectious cases. High-risk patients require close follow up, as nutritional supplementation and extended courses of antibiotics may be necessary.

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