CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 444, pp. 60–65

Treatment of Tuberculous Spondylitis with Anterior Stabilization and Titanium Cage

Anastasios G. Christodoulou, MD, PhD; Panagiotis Givissis, MD, PhD; Dimitrios Karataglis, MD; Panagiotis D. Symeonidis, MD; and John Pournaras, MD, PhD

We retrospectively reviewed 12 patients with spinal tuberculosis of the thoracic and lumbar spine who had radical débridement, anterior decompression, interbody arthrodesis with an anterior interbody titanium cage, and autologous bone grafts, combined with a standardized perioperative antituberculous regimen. Their mean age was 55.1 years and they were observed for a mean of 65.3 months. Indications for surgery included epidural abscess, structural destruction with instability, progressive kyphosis, and/or neurologic deterioration. Kyphotic deformity was corrected from a mean of 24.6° (range, 15°–32°) to a mean of 10° (range, 4°–18°). Tuberculous infection was controlled and bony fusion was achieved in all patients. No recurrence of infection or construct failure was recorded. All patients were safely mobilized within the first postoperative week; back pain fully resolved in eight patients and improved in the remaining four. We conclude that radical débridement followed by anterior stabilization with a titanium cage and bone grafting is a reasonable alternative for tuberculous spondylitis requiring surgical treatment. It enables accurate and lasting deformity correction and provides adequate stability to allow early mobilization. The presence of a titanium cage in an area of mycobacterial infection did not preclude infection control or lead to recurrence.

Level of Evidence: Therapeutic study. Level IV (case series). Please see Guidelines for Authors for a complete description of levels of evidence.

From the First Orthopaedic Department, Aristotelian University of Thessaloniki, "G. Papanikolaou" General Hospital, Thessaloniki, Greece.
Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
Correspondence to: Anastasios G. Christodoulou, MD, PhD, 58, J. Kennedy Str, 55535 Pylaia, Greece. Phone: 0030-2310-301863; Fax: 30-2310-358292; E-mail: givissis@med.auth.gr.
DOI: 10.1097/01.blo.0000201175.87635.28

The clinical presentation of tuberculous spondylitis is variable, but symptoms are typically less severe than in pyogenic infections[7,22] Persistent back pain is the most consistent symptom; generalized malaise, fever, and night sweats can also be present.[2,3] Laboratory studies and plain radiographs offer diagnostic help, but they are nonspecific.[7,22,26] Magnetic resonance imaging (MRI), especially after intravenous administration of gadolinium, has high specificity and sensitivity.[4,7,15,26] MRI has revolutionized early diagnosis and accurate evaluation of the extent of spinal infection spread and tissue destruction.[4,7,15,26] However, tissue biopsy and culture are of paramount importance to establish a definitive diagnosis and initiate antituberculous chemotherapy.[6,22] Antituberculous chemotherapy leads to a favorable outcome in a considerable number of patients by preventing abscess formation, deformity, structural instability, and neurologic deterioration.[22]

Surgical débridement and stabilization is considered in many patients with progressive deformity, abscess formation and/or neurologic deterioration.[14] Stabilization for deformity correction and maintenance can be obtained either with bone grafts alone or with a combination of grafts and posterior or anterior instrumentation.[9,10,18,19,23–25] Authors of experimental studies have shown anterior instrumentation offers superior and more dependable restoration of structural stability compared with bone graft alone or posterior instrumentation.[11,12]

However, the use of spinal instrumentation has been linked with increased risk of deep wound infection ranging from 2% to 9%.[18,21] Therefore, the placement of implants in an infected area remains controversial, in part because of questions as to whether the implants interfere with control of the infection.[5,9,13,20,25] This has led a number of authors to treat spondylitis in two stages, initially performing débridement and bone grafting followed by delayed instrumented fusion.[4,8,10,19] Despite these reports, we believe that the mid-term and long-term results of radical

surgical débridement, autologous bone grafting, and anterior stabilization using a titanium cage in patients with spinal tuberculosis and a deteriorating kyphotic deformity have not been studied adequately.

We asked whether anterior instrumentation could be used in the face of infection to correct and maintain kyphotic deformity and control infection and pain.

MATERIALS AND METHODS

We retrospectively reviewed 12 patients with tuberculous spondylitis of the thoracic and lumbar spine treated by radical surgical débridement, anterior decompression, and interbody arthrodesis with the aid of an anterior titanium interbody cage and autologous bone grafts; these patients were treated between January 1989 and December 2003. Three patients were men and nine were women, with ages ranging from 27 to 84 years (mean, 55.1 years). Patients were examined clinically and radiographically for a minimum of 1 year; deformity correction, pain, the course of infection, and neurologic status were recorded. The mean followup period was 65.3 months (range: 12 to 183 months). An 84-year-old patient died 14 months postoperatively from unrelated causes. This patient was included in our study because he had a full clinical and radiographic followup for 12 months and complete symptom resolution on final review. We had no control group.

The thoracic spine was involved in eight patients and the lumbar spine in four. The main indication for surgery was an epidural abscess, neurologic deficit, structural destruction of the anterior and middle vertebral columns resulting in instability, or progressive kyphosis. Persistent back pain was present in all 12 patients; four patients had developed paraparesis before their operation.

Fig 1. A preoperative lateral radiograph shows endplate destruction, disc obliteration, and kyphotic deformity in T6-T7 tuberculous spondylitis.

Plain anteroposterior (AP) and lateral radiographs, MRI, or CT scans confirmed spondylodiscitis in all 12 patients (Figs 1, 2). A percutaneous needle biopsy was performed in all patients before initiation of appropriate treatment. Tissue specimens retrieved during the biopsy were sent for histopathological examination and cultures. Patients' diagnoses were confirmed through positive histopathological sections that showed Langerhans giant cells, granulomatous tissue, and caseating necrosis. Cultures in a typical Löwenstein–Jensen culture media were taken in all patients; they were positive in five patients.

All procedures were preformed by the same surgeon (AC). A transpleural approach was used when the thoracic spine was affected, and a retroperitoneal approach was used when the lumbar spine was involved. We used a titanium mesh cage (DePuy Spine, Leeds, UK) with the Moss–Miami uniaxial screw and rod system (DePuy Spine, Leeds, UK) for augmentation of anterior stabilization (Fig 3). Structural stability was secured with the anterior instrumentation, which obviated the need for structural bone grafts. Nonstructural corticocancellous bone grafts from the resected ribs or the anterior iliac crest were used to fill the cage. The graft was also placed anterior to the cage to promote and expedite bony fusion. Patients were mobilized during the first postoperative week with the aid of a molded Boston type brace.

All patients were started on antituberculous chemotherapy preoperatively after confirmation of the diagnosis by positive culture or histologic results. Antituberculous treatment was continued for up to 9 months postoperatively. The regimen included streptomycin (1 g per day for 1 month and 1 g every alternate day for 1 month), rifampicin (600 mg per day for 9 months), isoniazid (300 mg per day for 9 months), and pyrazinamide (1.5 g per day for 2 months). Streptomycin and pyrazinamide were discontinued at 2 months and were replaced by ethambutol (1.2 g per day) for another 7 months. Liver and renal functions were monitored regularly throughout this period. Patients' hearing function was checked during the first 2 months when streptomycin was administered.

The segmental kyphosis angle was measured on lateral radiographs as the angle between the superior endplate of the first uninvolved vertebra proximal to the affected segment and the first uninvolved vertebra distal to the affected segment. Anteroposterior (AP) and lateral radiographs were taken immediately after surgery, at 6 weeks, 3 months, 6 months, and 12 months postoperatively, and yearly thereafter. All radiographs were reviewed by the same observer (DK), who was not involved in the operative procedure and was blinded to the clinical outcome. The presence of fusion was determined from two plain radiographs, and was further verified with CT scans in some patients (Fig 4).

Clinical evaluation was done by another observer (PS), who was also not involved in the operative procedure and was blinded to the radiographic outcome. The patients' preoperative and

Fig 2. Magnetic resonance imaging shows a paravertebral and epidural abscess with anterior spinal cord compression.

postoperative neurologic status was monitored and documented according to the American Spinal Injury Association (ASIA) Impairment Scale (AIS).[1]

Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were monitored regularly to exclude the presence of active disease process. Antituberculous chemotherapy was discontinued after nine months, provided the above tests were within normal limits.

RESULTS

The average operating time was 3.2 hours (range, 2–4.5 hours), and the average postoperative hospitalization was 18.3 days (range, 10–26 days).

The preoperative segmental kyphosis improved postoperatively from a mean of 24.6° (range, 15°–32°) to 10° (range, 4°–18°). Correction was maintained in eight patients but loss of correction of up to 3° occurred in three patients. One patient had persistent back pain and instability and radiographs taken 6 months postoperatively showed 5° loss of correction. We performed subsequent posterior stabilization that prevented further deformity propagation and eventually resolved the symptomatic instability. Bony fusion was seen in all patients on final followup, and no patient had implant subsidence or dislodgement.

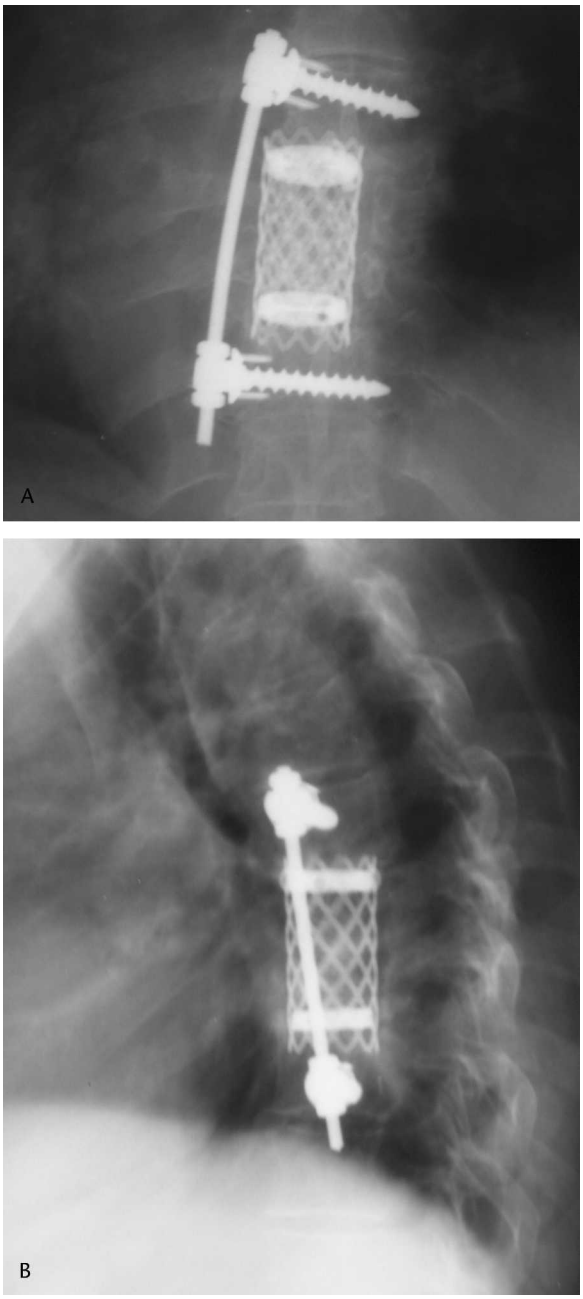

Fig 3A–B. (A) Postoperative AP and (B) lateral plain radiographs of the thoracic spine show T5 to T8 anterior interbody arthrodesis and instrumentation using titanium cage and autologous bone grafting.

Fig 4. A CT scan 3 years postoperatively shows graft incorporation and bony fusion.

Patients were successfully mobilized within the first postoperative week with the aid of a specially molded Boston-type brace. The use of the brace was discontinued by 3 months postoperatively in all patients except for the one patient with continuing back pain, instability, and subsequent posterior stabilization.

Infection control was achieved in all patients and no recurrence was recorded. Erythrocyte sedimentation rate, CRP and white blood cell (WBC) counts returned to normal within 6 months in all patients and remained within normal limits thereafter.

Back pain fully resolved in eight of 12 patients and the remaining four reported improvement compared with their preoperative conditions. Of the four patients who developed paraparesis before their operations, three improved according to the ASIA AIS from Grade AIS D to AIS E. One patient did not have substantial improvement and remained Grade AIS C.

There were no major postoperative complications. Two patients developed atelectasis after thoracotomy and one patient developed ileus after a retroperitoneal approach. These fully resolved with intensive chest physiotherapy and use of a nasogastric tube.

DISCUSSION

Tuberculous spondylitis mainly affects the anterior column of the spine and is more common in patients with compromised immune function and elderly patients.[20,22] Its clinical presentation is variable, but a high index of suspicion and MRI has led to early diagnosis and initiation of antituberculous chemotherapy.[15,16,22] Tissue biopsy and culture remains important in securing a definitive diagnosis and should always be obtained before the appropriate medical treatment is initiated.[6,20,22,25] Early initiation of the proper antituberculous medication coupled with tissue resting leads to a favorable outcome in most patients.[20] Surgical débridement and stabilization is indicated in the presence of an epidural abscess, neurologic deficit because of compression, structural destruction resulting in instability, or when antituberculous chemotherapy has failed.[13,14,20] In patients requiring surgical treatment, the use of anterior instrumentation offers the theoretical advantage of more reliable deformity correction and safer mobilization but has also been linked with an increased risk of infection, although this notion has been challenged by some results.[8,9,19,24]

This study is retrospective and the absence of a control group limits our ability to ensure similar results might not be obtained with alternative treatments. The fact that all patients were operated on by the same surgeon during a specific time period, however, provides us with a patient population that is homogenous regarding pathology, operative technique, and postoperative regime. Also, patients were observed for a mean > 5 years and were assessed by two blinded independent observers with a variety of outcome measures. These factors allow us to draw meaningful conclusions.

Adequate débridement of pus, caseous material, necrotic bone and sequestra, and subsequent stabilization of the involved spinal segments are vital for infection control.[22] Débridement combined with concurrent antituberculous chemotherapy but not coupled with bone grafting or instrumented stabilization can help infection control but does not prevent the development or progression of deformity.[13,23,24]

The Hong Kong operation on the other hand, involves radical débridement of the infected bone and correction of the kyphotic deformity using a structural bone graft (rib or tricortical bone graft). This procedure yields very satisfactory results.[23,24] It provides a relatively stable biomechan-

ical environment although stability relies solely on the structural grafts. Patients may require prolonged immobilization or even additional posterior instrumentation in order to protect structural stability until bony fusion has occured.[9,23,24] If posterior instrumentation is performed after débridement for spondylodiscitis, this must be done in a sequential or two-stage procedure through a separate approach.[8,10,19] It also has been shown in an unstable calf model that a relatively long fusion is required after corpectomy to restore adequate stability by means of posterior instrumentation alone.[11]

An appealing alternative would be to perform radical débridement and simultaneously combine it with instrumented anterior stabilization. Gurr et al[12] have shown in an experimental biomechanical study in a corpectomy model that anterior instrumentation offers superior and more dependable restoration of structural stability compared with bone graft alone or posterior instrumentation. Anterior instrumentation necessitates fusion of only one or two levels and can be performed through the same approach used for débridement. The presence of implants in the infected area, however, is a matter of debate because although implants help provide structural stability, the presence of foreign material in an area of infection may undermine efforts to eradicate the infection[9,19,25] Authors of experimental studies suggest Mycobacterium tuberculosis, unlike bacteria, has low adherence to stainless steel and forms less polysaccharide biofilm.[17] Therefore, the use of implants in the presence of mycobacterial infections may be relatively safe .

The use of a cage and bone grafts instead of a structural bone graft alone allows for more secure, accurate, and dependable deformity correction.[9,23–25] The cage provides a more rigid fixation construct and minimizes the risk of graft subsidence or dislodgement, that are well-documented complications when structural bone graft alone is used.[9,19,23,24] It also provides stability in the region, ensuring tissue rest and enabling earlier and safer mobilization.[9,25] Yilmaz et al[25] recently reported promising short-term results in a series of patients where a variety of implants and strut grafts were used for anterior stabilization after radical débridement in patients with tuberculous spondylitis.

We used a more uniform approach with a titanium cage in conjunction with nonstructural bone grafts after radical débridement. Because the posterior elements were intact, additional posterior stabilization leading to 360° of fusion was not necessary except in one patient. The postoperative deformity correction achieved in our series compares favorably with that reported when only structural bone grafts or a combination of grafts and posterior instrumentation were used.[13,19,23,24] More important, unlike other series, deformity correction was maintained and no implant subsidence, graft dislodgement, or resorption was recorded.[9,19,23,24] All patients were mobilized safely shortly after surgery because the increased stability offered by the titanium cage used obviated the need for prolonged bed rest. Tuberculous infection was controlled and bony fusion was achieved in all patients and substantial pain relief was obtained in the majority of patients.

We believe the apparently increased stability offered with this method may lead to a more favorable environment for infection eradication, graft incorporation, and solid fusion (Figs 3,4). Titanium alloys generally are considered relatively friendly toward the host bone and are reported to have lower infection risk.[21] Mycobacterium tuberculosis has low adherence properties towards stainless steel,[17] but its behavior towards titanium has not been studied yet. Data from this patient series suggest M. tuberculosis may well behave toward titanium implants in a similar fashion as toward stainless steel implants as far as its adherence properties are concerned.

Radical débridement followed by instrumented anterior stabilization and bone grafting offers very satisfactory results in selected patients with tuberculous spondylitis having an indication for surgical intervention. It provides adequate stability, offers lasting deformity correction, and enables early and safe mobilization. Concerns that the presence of implants in an area of mycobacterial infection may jeopardize infection control have not been confirmed, apparently because of the low adherence properties of M. tuberculosis to metal.

References

1. American Spinal Injury Association. International standard for neurological and functional classification of spinal injury. Chicago, ASIA 1992.
2. Buchelt M, Lack W, Kutschera HP, Katterschafka T, Kiss H, Schneider B, Kotz R. Comparison of tuberculous and pyogenic spondylitis: An analysis of 122 cases. *Clin Orthop Relat Res.* 1993; 296:192–199.
3. Calderone RR, Larsen JM. Overview and classification of spinal infections. *Orthop Clin North Am*. 1996;27:1–8.
4. Carragee EJ. The clinical use of magnetic resonance imaging in pyogenic vertebral osteomyelitis. *Spine*. 1997;22:780–785.
5. Carragee EJ. Instrumentation of infected and unstable spine: A review of 17 cases from the thoracic and lumbar spine with pyogenic infections. *J Spinal Disord*. 1997;10:317–324.
6. Christodoulou A, Zidrou C, Savvidou OD, Givissis P, Apostolou T, Mavrogenis AF, Papagelopoulos PJ, Pournaras J. Percutaneous Harlow Wood needle biopsy of the spine: A retrospective analysis of 238 spinal lesions. *Orthopedics*. 2005;28:784–789.
7. Colmenero JD, Jimenez-Mejias ME, Sanchez-Lora FJ, Reguera JM, Palomino-Nicas J, Martos F. Garcia de las Heras J, Pachon J. Pyogenic, tuberculous and brucellar vertebral osteomyelitis: A descriptive and comparative study of 219 cases. *Ann Rheum Dis*. 1997;56: 709–715.
8. Dimar JR, Carreon RY, Glassman SD, Campbell MJ, Hartman MJ, Johnson JR. Treatment of pyogenic vertebral osteomyelitis with anterior debridement and fusion followed by delayed posterior spinal fusion. *Spine*. 2004;29:326–332.
9. Faraj AA, Webb JK. Spinal instrumentation for primary pyogenic

infection: Report of 31 patients. *Acta Orthop Belg*. 2000;66:242–247.
10. Fukuta S, Miyamoto K, Masuda T, Hosoe H, Kodama H, Nishimoto H, Sakaeda H, Shimizu K. Two stage (posterior and anterior) surgical treatment using posterior spinal instrumentation for pyogenic and tuberculotic spondylitis. *Spine*. 2003;28:E302–E308.
11. Gurr KR, McAfee PC, Shih CM. Biomechanical analysis of posterior instrumentation systems following laminectomy: An unstable calf spine model. *J Bone Joint Surg*. 1988;70:680–691.
12. Gurr KR, McAfee PC, Shih CM. Biomechanical analysis of anterior and posterior instrumentation systems following corpectomy: A calf spine model. *J Bone Joint Surg*. 1988;70:1182–1191.
13. Jain AK. Treatment of tuberculosis of the spine with neurologic complications. *Clin Orthop Relat Res.* 2002;398:75–84.
14. Krodel A, Sturz H, Siebert CH. Indications for and results of operative treatment of spondylitis and spondylodiscitis. *Arch Orthop Trauma Surg*. 1991;110:78–82.
15. Maiuri F, Iaconetta G, Gallicchio B, Manto A, Briganti F. Spondylodiscitis: Clinical and magnetic resonance diagnosis. *Spine*. 1997; 22:1741–1746.
16. McHenry MC, Easley KA, Locker GA. Vertebral osteomyelitis: Long term outcome for 253 patients from seven Cleveland-area hospitals. *Clin Infect Dis*. 2002;34:1342–1350.
17. Oga M, Arizono T, Takasita M, Sugioka Y. Evaluation of the risk of instrumentation as a foreign body in spinal tuberculosis: Clinical and biologic study. *Spine*. 1993;18:1890–1894.
18. Przybylski GJ, Sharan AD. Single-stage autologous bone grafting and internal fixation in the surgical management of pyogenic discitis and vertebral osteomyelitis. *J. Neurosurg (Spine 1).* 2001;94: 1-7.
19. 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 in the lumbar spine. *Spine*. 1998;23:1885–1890.
20. Schinkel C, Gottwald M, Andress H-J. Surgical treatment of spondylodiscitis. *Surg Infect.* 2003;4:387–391.
21. Soultanis K, Mantelos G, Pagiatakis A, Soucacos PN. Late infection in patients with scoliosis treated with spinal instrumentation. *Clin Orthop Relat Res.* 2003;411:116–123.
22. Tay BK-B, Deckey J, Hu S. Spinal infections. *J Am Acad Orthop Surg*. 2002;10:188–197.
23. Upadhyay SS, Sell P, Saji M, Hsu LC. Surgical management of spinal tuberculosis in adults: Hong Kong operation compared with debridement surgery for short and long term outcome of deformity. *Clin Orthop Relat Res.* 1994;302:173–182.
24. Upadyahay SS, Sell P, Saji MJ, Sell B, Yau C, Leong JCY. 17-year prospective study of surgical management of spinal tuberculosis in children: Hong Kong operation combined with debridement surgery for short- and long-term outcome of deformity. *Spine*. 1993;18: 1704–1711.
25. Yilmaz G, Selek HY, Gurkan I, Erdemli B, Korkusuz Z. Anterior instrumentation for the spinal tuberculosis. *J Bone Joint Surg*. 1999; 81:1261–1267.
26. Wirtz DC, Genious I, Wildberger JE, Adam G, Zilkens KW, Niethard FU. Diagnostic and therapeutic management of lumbar and thoracic spondylodiscitis: An evaluation of 59 cases. *Arch Orthop Trauma Surg*. 2000;120:245–251.