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Evaluation of the Risk of Instrumentation as a Foreign Body in Spinal Tuberculosis

Clinical and Biologic Study

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The risk of persistence and recurrence of infection in posterior spinal instrumentation surgery for spinal tuberculosis was studied clinically and microbiologically. Eleven patients with thoracic, thoracolumbar, and lumbar spinal tuberculosis treated by debridement, anterior fusion, and combined posterior instrumentation surgery were analyzed. Seven patients had tuberculosis in both anterior and posterior spinal elements. There were no cases of persistence or recurrence of infection after surgery, and instrumentation provided immediate stability and protected against development of kyphotic deformity. The adherence properties of Mycobacterium tuberculosis to stainless steel (SUS 316) was evaluated experimentally. The results showed that posterior instrumentation surgery was not a hazard to spinal tuberculosis infection when combined with radical debridement and intensive anti-tuberculosis chemotherapy. [Key words: spinal tuberculosis, instrumentation, foreign body infection]

The development of anti-tuberculous chemotherapy revolutionized the treatment of patients with spinal tuberculosis in the 1950s, but could not satisfactorily prevent the associated kyphotic deformity.[11,15] When more than two disc spaces were involved, the anterior strut graft tended to fail and the kyphotic deformity commonly occurred. In such cases we used posterior spinal instrumentation to achieve immediate stability, augumented with anterior debridement and spine fusion. In infectious diseases, instrumentation introduces a foreign body, which can become a focus of organisms and cause persistence of infection.[4,5]

Recently, microbiologically biomaterial-centered infections are believed to be related, in part, to preferential adhesive bacterial colonization of inert surfaces.[14] There are few articles that study instrumentation surgery for spinal tuberculosis.

Therefore, we evaluated the risk of biomaterial-induced infection of instrumentation surgery for spinal tuberculosis clinically and microbiologically.

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Materials and Methods

From 1965 to 1991, 79 spinal tuberculosis patients were treated surgically in our hospital. Eleven of these patients, treated with posterior instrumentation from 1979 to 1991, were analyzed in this report.

There were 3 male and 8 female patients with an average age of 44 years (range, 15–62). The average duration of symptoms before referral was 18 months (range, 1 month to 4 years). The average length of follow-up was 6 years (range, 1–12 years). All patients had taken standard laboratory tests, which included a blood cell count, erythrocyte sedimentation rate, blood chemistry profile, and Mantoux tuberculin skin test.

All patients had plain film radiographic evaluation. Special studies including bone scans, tomograms, myelograms, and computed tomographic scans were performed as clinically indicated. Biopsy was done when necessary to establish the diagnosis.

Surgical Procedure. Posterior instrumentation surgery included eight Harrington rods with sublaminar or spinous process wiring (HSSI) and three Cotrel-Dubousset Instrumentations. Posterior instrumentation surgery was performed first followed by anterior debridement and fusion. A single-stage operation was done in four patients and a two-stage operation was done in seven patients. In the two-stage operation, anterior surgery was performed 2–4 weeks after posterior instrumentation surgery. One of the patients who had a single-stage operation had surgical posterior abscess drainage 2 months before the operation. Posterior abscess drainage was performed at posterior instrumentation surgery in three patients.

Biomaterial. Circular stainless steel discs (SUS 316), 10-mm diameter, were used as biomaterials. All discs were cleaned by sonication and sterilized with ethylene oxide.

Bacterial Culture. A strain of Staphylococcus epidermidis (SE-46), isolated by K. Iwata (1986)[17] from a biomaterial-centered infection and Mycobacterium tuberculosis isolated from spinal tuberculosis patients and RDH37 strain were used. The S. epidermidis was cultured for 48 hours in 500 ml Trypticase soy broth without dextrose (Difco Laboratories, Detroit, MI), supplemented with 0.5% gluconic acid (Sigma Scientific, St. Louis, MO).

Twenty milliliters of bacterial suspension standardized by our method[14] was used to inoculate 2.0 ml of batch culture.

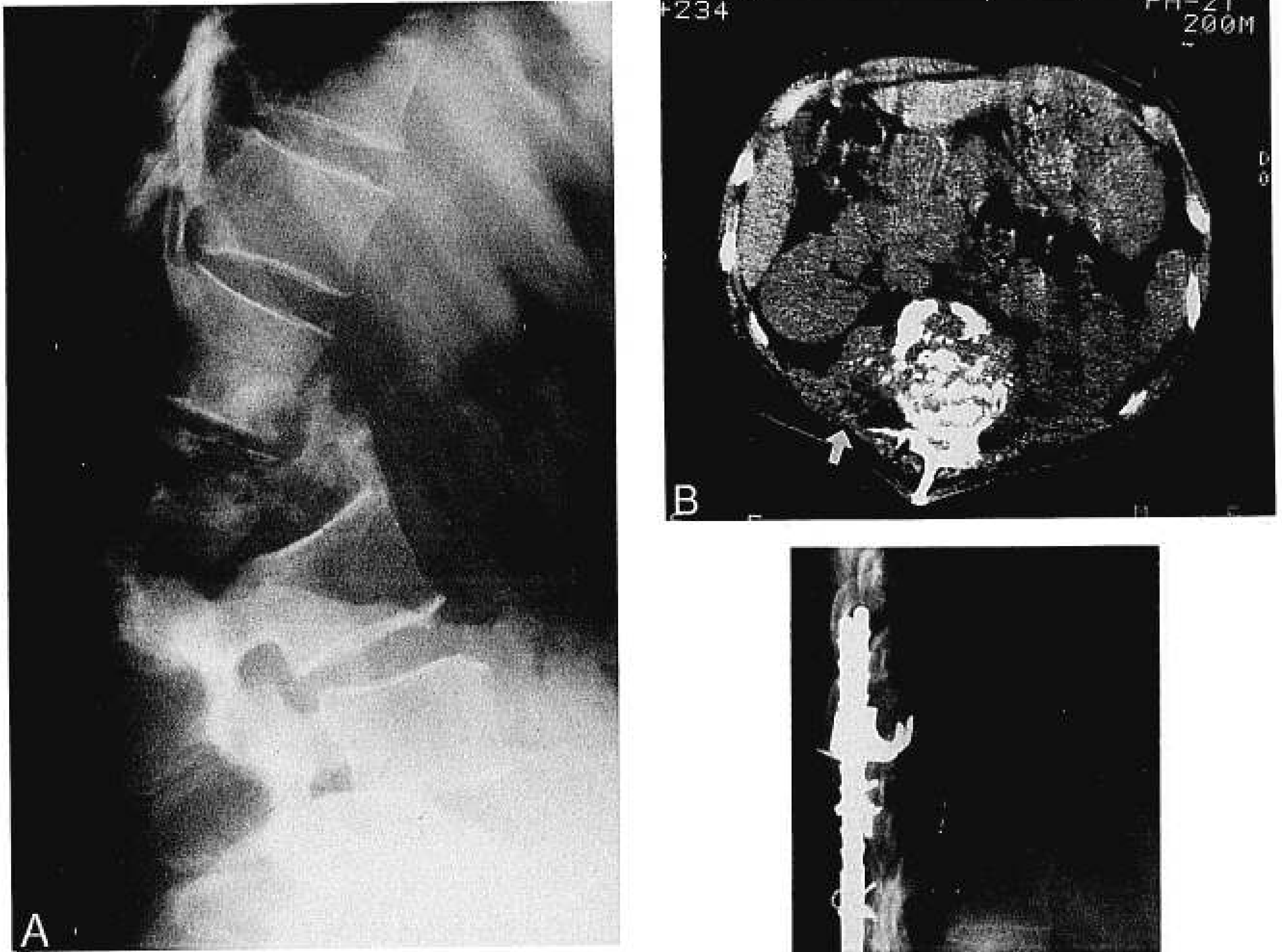

Figure 1. A 47-year-old woman with tuberculosis from L1 to L3. **A,** Roentgenogram showing a destructive vertebral lesion (L1, L2) and severe kyphotic deformity. **B,** Computed tomography of L2. Bilateral paravertebral abscesses, destruction of the vertebral body and bilateral pedicules are seen. A soft tissue abscess extends dorsally (arrow). **C,** Radiograph made 7 years after one-stage anterior and posterior fusion with correction of kyphosis. There is bone fusion from T12 to L3.

The number of bacteria in the incubation suspension at the beginning of the experiment was about 6×10^7 to 10^8 CFU/ml. Mycobacterium tuberculosis strain RDH37 and the clinical strain were initially cultured separately on a slant of 3% Ogawa medium (Nissui pharmaceutical Co. Ltd., Tokyo) at 37 C for 2 weeks. The former strain has been maintained in our laboratory and the latter strain was isolated from a patient. Both strains produce niacin. Each part of the Ogawa medium culture was transferred to a test tube containing Dubos Tween-albumin broth (Eiken Chemical Co. Ltd., Tokyo). The two tubes were cultured with shaking at 37°C for one week.

Experimental Design. Six stainless steel discs were individually placed in 100 ml TSB containing 10^8 CFU/ml of S. epidermidis SE46 and incubated at 37 C for 24 hours. Each of six stainless steel discs were also individually placed in 100 ml Dubos Tween-albumin broth containing Mycobacterium tuberculosis strain RDH37 or the clinical strain and incubated at 37 C for 3 days.

At the end of the incubation period, the individual discs were aseptically removed from the media and washed five times with 10 ml phosphate-buffered saline per wash to remove any nonadherent organisms. They were then placed in 0.1 M cacodylate buffer containing 5% glutaraldehyde and 0.15%

Table 1. Clinical Details of Spinal Tuberculosis Patients

					ESR (mm)		
Case	Age	Sex	Level of Pathology	Level of PIF	Preop	Postop 6M	Neurodeficit
1	53	F	L2-L3	T12-L5	45	24	No
2	38	M	T9-T10	T5-L3	6	2	Yes
3	47	F	L1-L3	T10-L5	21	8	Yes
4	63	F	L4-L5	L1-S	26	12	No
5	60	F	T12-S1	T9-S	47	21	Yes
6	15	M	T10-L2	T7-L3	4	7	No
7	39	M	T12-L1	T9-L3	14	4	No
8	35	F	T8-T10	T5-L1	18	13	No
9	58	F	L2-S1	T12-S	63	25	Yes
10	35	F	L1-L4	T12-L5	78	17	No
11	43	F	T7, L3-L5	T4-S	20	10	Yes

PIF: posterior instrumentational fusion.
ESR: erythrocyte sedimentation rate.

ruthenium red and incubated at room temperature for 2 hours. Samples were developed by our method described previously[5,14] and examined with a Hitachi S-700 scanning electron microscope (SEM).

Clinical Results

Preoperative laboratory studies showed an average white blood cell count of 6,700 (range, 4,740–9,200) and erythrocyte sedimentation rate (ESR) of 31 mm/hour (range, 4–78 mm/hour).

The source of infecting organs could be identified in five patients. These sources were the lungs in three and the kidneys in two. The Mantoux tuberculin test was positive in 10 of 11 patients. The average number of vertebral bodies that were radiographically involved was 3.5 (range, two to seven). All patients showed uptake at the site of the spinal lesion on bone scan. Five patients were found to have tuberculosis in the posterior elements evaluated by CT scan and MRI (Figure 1), and an abscess was drained from the posterior elements at surgery in two of them. Five patients exhibited neurological impairment. Two patients had cord compression with long tract signs when initially evaluated. All of them recovered after surgery. Six patients underwent needle biopsy of a spinal vertebrae under radiographic control and local anesthesia. One had a negative culture and negative smear for tuberculosis. All specimens were positive histologically. The average number of posterior fused vertebrae was 8.5 (range, 6–15) (Table 1). Infection subsided after surgery, and there were no cases of recurrence. The average erythrocyte sedimentation rate 6 months after surgery was 13 mm/hour (range, 8–25 mm/hour).

Anterior strut grafted bone was incorporated and fused. No kyphotic spinal deformity occurred after surgery.

Microbiologic Results

Observation of scanning electron microscopy (SEM) showed that the surface of the stainless steel was heavily colonized by Staphylococcus E-46 cells and covered by a thick adherent biofilm. Matrix-enclosed microcolonies developed on the biomaterial surface and eventually formed an extensive and coherent matrix (Figure 2). Conversely, there were few Mycobacterium tuberculosis, either RDH37 or clinical strain, adherent to the stainless steel and there was a little thin adherent biofilm observed (Figure 3). These findings were uniform throughout all the samples examined.

Discussion

In 1934, Ito et al[7] described anterior spinal fusion for the treatment of spinal tuberculosis. Hodgson and Stock[6] reported their findings in 1960. Since then, anterior debridement and fusion has been the choice for the surgical treatment of spinal tuberculosis. In spinal tuberculosis, it is not unusual that two or three vertebrae are involved. Rajasekaran et al[15] stated that failure of the graft was very common in patients who had a lesion involving more than two vertebral bodies.

When the focus extended to more than two vertebrae, radical debridement created a large deficit in the anterior structures and produced spinal instability.[12] If the anterior strut graft then failed, kyphotic deformity was induced. Bailey et al[2] reported that they seriously considered performing supplementary posterior arthrodesis whenever the anterior graft bridged more than two vertebral segments. Kemp et al[10] usually perform a posterior fusion if there is destruction of two or more vertebral bodies, or if there is instability due to destruction of the posterior vertebral elements.

In such cases, we have used posterior instrumentation because it achieves immediate stability and helps to maintain the correction until the fusion is complete. The instrumentation surgery for infectious disease is accompanied by the risk of causing persistent infections, however, particularly when the posterior vertebral elements are involved.[1,16]

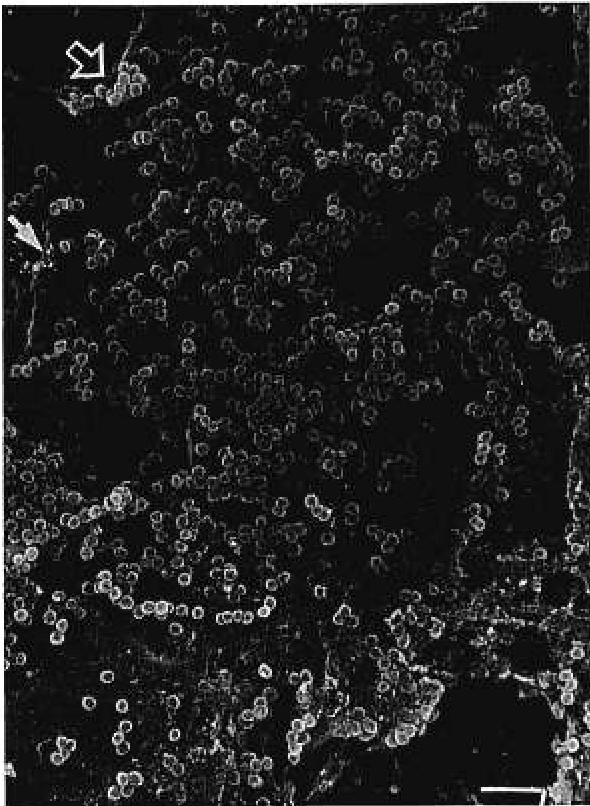

Figure 2. Scanning electron micrograph of stainless steel exposed to S. epidermidis (SE-46). Note the formation of S. epidermidis microcolonies (white and black arrow) and amorphous adherent biofilm (white arrow). Bar = 5 μm.

Figure 3. Scanning electron micrograph of stainless steel exposed to Mycobacterium tuberculosis (clinical strain). There are few adherent rod-shaped organisms (white and black arrow) and thin biofilm (white arrow) adherent on the surface of the stainless steel. Bar = 5 μm

In infectious diseases, instrumentation introduces a foreign body that acts as a focus, and the infection is notoriously resistant to antibiotic therapy and usually requires removal of the instrument.

Microbiologically, biomaterial-centered infections are believed to be related, in part, to preferential adhesive bacterial colonization of inert surfaces.[14] Recent studies have clearly implicated adhesive, slime-producing bacterial colonization of inert surfaces.[4,5,14] Microorganisms first attach hematogenously or directly from the infected tissue to the inert surface where they colonize. Then they produce an extrapolysaccharide biofilm that protects the organisms from host defense mechanisms and antibioics.[3] In our experiment, SEM examination showed extensive colonies of S. epidermidis and a thick adherent biofilm on the surface of the stainless steel.

Conversely, Mycobacterium tuberculosis was less adhesive, and only a few biofilm-covered microcolonies were observed.

The outer layer of the microorganisms, the effects of the bacterial adherence property, and ability to produce extra-polysaccharide differ with the organism. Mycobacterium may have different adhesive properties and adhesive action to biomaterial surfaces than other bacteria and produce less biofilm. Mycobacterium tuberculosis adherent to the biomaterial surfaces may resist host defense mechanisms and antibiotics, but not as strongly as other bacteria.

Clinically, Johnson[9] reported two cases of tuberculosis reactivation after total hip replacement. In our series, however, the follow-up period was more than 3 years except in one case, good results were obtained in all cases, and there were no recurrences or persistence of infection. No collapse of grafted bone or kyphotic deformity were observed. Complete debridement of infectious tissue and intensive antituberculous chemotherapy can therefore eradicate tuberculous infection of the spine, even though biomaterial is present in the posterior vertebral portion.

In summary, both clinical and microbiologic results suggest that posterior instrumentation is not associated with persistence or recurrence of spinal tuberculous infection and is useful to provide immediate stability and protect against the development of kyphotic deformity.

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