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Tuberculosis of the Musculoskeletal System

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Summary: Tuberculosis remains a major source of morbidity and mortality worldwide, and orthopaedic surgeons working in developing nations, especially in South East Asia, are likely to encounter patients with osteoarticular manifestations of the disease. Chemotherapy is effective, and surgery serves as an adjunct for specific indications. Tuberculous osteomyelitis is the least common presentation, and the radiographic features may be confused with a variety of other diagnoses. A biopsy is required, and curettage may be performed in addition to chemotherapy. Bone Grafting is generally not required. The natural history of articular disease evolves over several years from a synovitis to joint destruction, and the prognosis is related to the stage of disease at presentation. In addition to chemotherapy, a synovectomy may be indicated in patients who have synovitis without significant joint destruction. For later stage disease, salvage options include osteotomy, arthrodesis, or prosthetic reconstruction. Approximately 50% of patients will have spinal involvement, and chemotherapy is effective in the majority of cases. The indications for surgery remain somewhat controversial, but may include uncertainty with the diagnosis, lack of response to chemotherapy, profound or progressive neurologic deficit, mechanical instability, or progression of deformity.

Tuberculosis has been a health concern for several thousand years, and millions continue to be afflicted with this disease. Although the disease may be found on all continents, orthopaedic surgeons working in south and Southeast Asia are most likely to encounter cases of osteoarticular tuberculosis. Tuberculosis is most common in areas with crowding, poor sanitation, and malnutrition. An increase in tubercular infection has been associated with the prevalence of the acquired autoimmune deficiency syndrome as well. While most cases are seen during the first 3 decades of life, the elderly population is also susceptible. Only a small number of patients with tuberculosis will have osteoarticular involvement, half of which will have spinal disease. Although chemotherapy is highly effective, the most important variable predicting outcome is the stage of disease at presentation. Surgery is reserved for specific indications, most often to establish the diagnosis or to treat complications of the disease process. In addition, efforts should be made to improve the patient's general physiologic state. Our goal is to review the pathophysiology, clinical findings, diagnosis, and treatment options for osteoarticular tuberculosis.

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PATHOPHYSIOLOGY/NATURAL HISTORY

The primary focus of disease is visceral (lungs, kidneys, lymph nodes), and musculoskeletal involvement occurs via hematogenous spread.[70,71] Once deposited at a site, the organisms are ingested by mononuclear cells. Mononuclear cells then coalesce into epitheloid cells, and a tubercle is formed when lymphocytes form a ring around a group of epitheliod cells. Caseation then develops within the center of the tubercle. The host inflam-

matory response intensifies, resulting in exudation and liquefaction, and a cold abscess is formed. A cold abscess is composed of serum, leukocytes, caseation, bone debris, and bacilli. The outcome depends on the characteristics and sensitivity of the organism, the status of the host immune system, the stage of disease at presentation, and the treatment. The range of end results may include resolution with minimal or no morbidity, healed disease with residual deformity, walled off lesions with calcification of caseous tissue, a low-grade chronic granular lesion, and local or miliary spread of the disease that may result in death.[71]

CLINICAL FINDINGS

Constitutional symptoms include low-grade fevers, night sweats, weight loss, anorexia, and malaise. Musculoskeletal complaints include swelling, stiffness, and pain ("night cries" may wake the patient from sleep). Osseous involvement is associated with localized warmth, swelling, and tenderness. Articular involvement is associated with tenderness, soft tissue swelling/effusion, and restriction of movement. Findings in patients with spinal disease include back pain/tenderness, a neurologic deficit, and a kyphotic deformity. Swelling and tenderness over a synovial bursa (especially the greater trochanter) or tendon sheath is seen less frequently. Lymphadenopathy is common, and sinuses are frequently observed (Fig. 1A,B).

Management Principles

The first priority is to establish the diagnosis. In regions of the world where tuberculosis is endemic, a therapeutic trial using the principle of treating rather than testing and treating is preferred when the typical clinical and radiographic features are present. There are neither the resources nor the manpower to subject every patient to a biopsy. If a biopsy is performed, the diagnostic yield is the greatest when material is submitted for smear, culture, and guinea pig inoculation. Cultures may take up to 8 weeks, and are only positive in 30% to 60% of cases. The likelihood of identifying the organism on a smear is 10% to 30%. The Mantoux test will be positive in the majority of patients. Patients are often anemic, and the erythrocyte sedimentation rate is usually elevated. A chest radiograph should be ordered when the diagnosis is suspected or established. More advanced imaging studies may be unavailable, and in most cases are nondiagnostic.

Chemotherapy should be approximately 90% effective in eradicating the infection, provided that the appropriate agents are administered, and that patient compliance is ensured. Inadequate treatment and/or lack of compliance

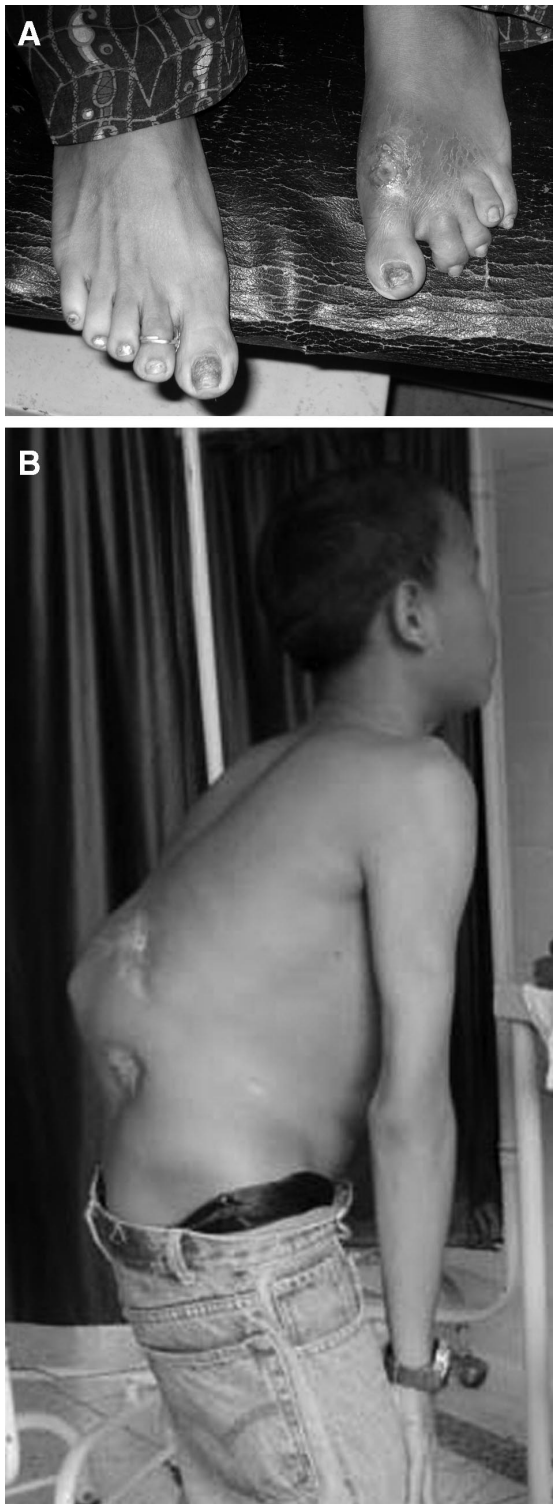

FIG. 1. (**A**,**B**) Sinuses are commonly observed with osteoarticular disease. An active sinus in the foot (**A**) demonstrates serosanguinous drainage. Sinuses usually heal with appropriate medical management, as shown in this patient with a significant kyphosis and evidence of multiple sinuses posteriorly.

will result in the emergence of resistant organisms. The management of recurrence/relapse is challenging, expensive, and may fail to eradicate the disease. In the DOTS (directly observed treatment) program, compliance is ensured by employing local health care workers to document the ingestion of each dose of medication.[5]

Although treatment protocols vary, the current trend has been to use intermittent dosing (2–3 times per week), and to decrease the overall duration of therapy from 18 months to 9 months.[5,55,59,69] Further study will be required to determine whether a shorter duration of therapy will be as effective for osteoarticular disease. Our recommended duration of therapy is usually 12 months, except for those with spinal disease, in whom we continue to recommend 18 months. Treatment is divided into two phases. During the first phase, 4 agents are administered for 2 to 3 months. In the second phase, 2 to 3 agents are prescribed over 4 to 6 months. Resistance to a single agent is in the range of 13%, and multidrug resistance is encountered in approximately 1% to 2%.[5,53] The treatment of relapse typically involves 5 agents in the first phase, and 3 agents during the second phase. Failure to respond to standard chemotherapeutic protocols, with compliance documented, usually suggests the presence of a resistant organism or an alternate diagnosis.

Antitubercular drugs have been grouped into first and second line agents.[5,67,69] First line agents include Isoniazid, Rifampicin, Streptomycin, Pyrazinamide, Ethambutol, and Thiocetazone. Second line agents Capreomycin, Kanamycin, Ethionamide, Cycloserine, and Para-amino-salicylic acid. These agents will penetrate a tubercular abscess.[76,77] Sinuses should heal within 6 to 12 weeks unless there has been a secondary bacterial infection.[38]

Tuberculous Osteomyelitis

Tuberculous osteomyelitis represents less than 5% of cases of osteoarticular tuberculosis. The duration of symptoms range from days to months, and coexisting visceral disease is uncommon.[34,38] Abscess formation may occur, and sinuses are common. Notable features of a tuberculous sinus include bluish discoloration at the periphery, undermined edges, sero-sanguinous discharge, matted draining lymph nodes, and fixation to bone.

Radiographically, tuberculosis may be confused with a host of conditions (Fig. 2). The lesion may be metaphyseal or diaphyseal, and may penetrate the physis or extend into an adjacent joint. The most common presentation is a solitary lytic lesion, usually with a sclerotic rim. The differential diagnosis includes Brodie's abscess, chronic osteomyelitis, granulomatous lesions, and neoplasia.[23,26,81] Sequestrae may be identified,[38,71] and an

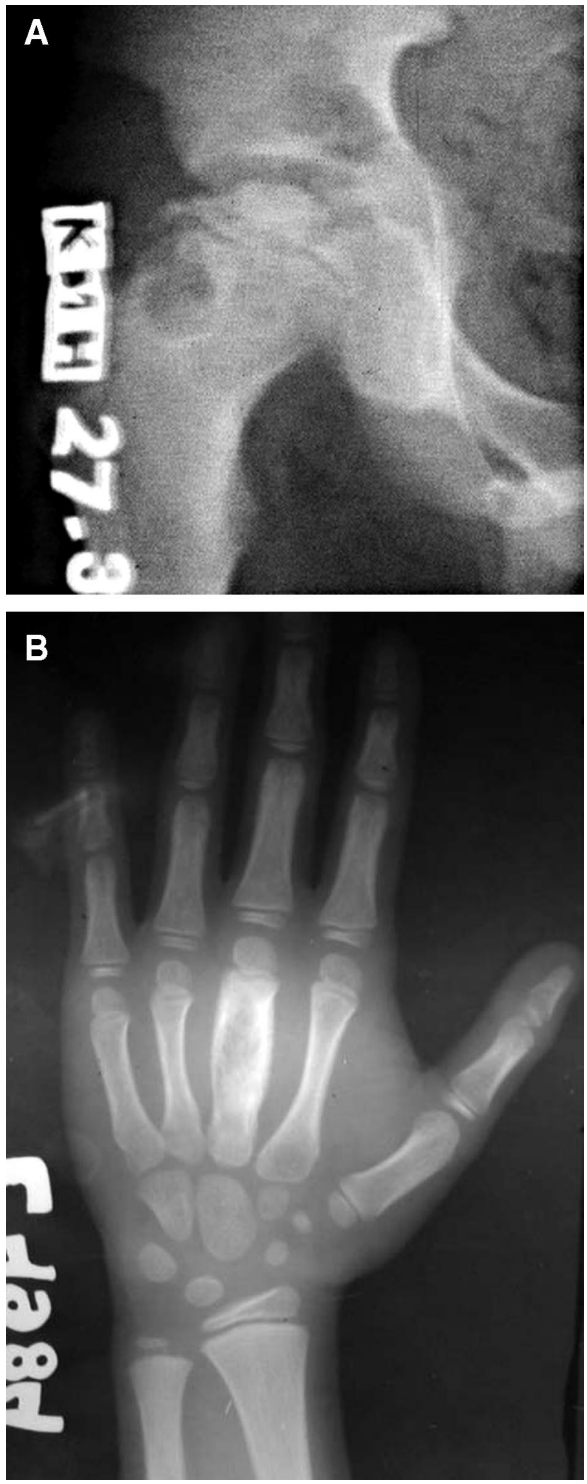

FIG. 2. (**A–B**) **Tuberculous Osteomyelitis.** The most common presentation is that of a lytic lesion with a sclerotic rim (**A**). Note the coexisting avascular necrosis. Spina ventosa (**B**) represents a rare form of tuberculous osteomyelitis in which a spindle shaped expansion of the short tubular bones of the hand and foot is seen in association with multiple layers of subperiostial new bone.

TABLE 1.
Tuli Classification. The Natural History of Tuberculous Arthritis Progresses Through 5 Stages [71]

	Clinical Findings	Radiographic Findings	Treatment	Anticipated Outcome
Stage I (Synovitis)	1.) Soft tissue swelling 2.) 75% motion preserved	1.) Soft tissue Swelling 2.) Osteopenia	1.) Chemotherapy 2.) Rest 3.) ROM 4.) Splinting	Normal or minimal residua
Stage II (early arthritis)	1.) Soft tissue Swelling 2.) 25–50% loss of motion	1.) Soft tissue swelling 2.) Marginal joint erosions 3.) Diminution in joint space	1.) Chemotherapy 2.) Rest 3.) ROM 4.) Splinting 5.) Synovectomy	50–70% mobility
Stage III (advanced arthritis)	1.) 75% loss of motion	1.) Marginal erosions 2.) Cysts 3.) Significant loss of joint space	1.) Chemotherapy 2.) Osteotomy 3.) Arthrodesis 4.) Arthroplasty	Stable, painless joint after salvage, with or without motion
Stage IV (advanced arthritis)	1.) 75% loss of motion 2.) Subluxation or dislocation	1.) Joint destruction	1.) Chemotherapy 2.) Osteotomy 3.) Arthrodesis 4.) Arthroplasty	Stable, painless joint after salvage
Stage V (Ankylosis)	1.) Ankylosis	1.) Ankylosis	1.) Chemotherapy 2.) Osteotomy 3.) Arthrodesis 4.) Arthroplasty	Stable, painless joint

aggressive periostial response may be observed.[23,38] In children, intraosseous thrombosis may result in sequestration of the diaphysis, which may easily be confused with chronic bacterial osteomyelitis.[71]

Unusual forms of skeletal tuberculosis include multiple cystic tuberculosis (one or more large, oval areas of rarefaction, children),[23,33,66] disseminated skeletal tuberculosis (multiple osseous and/or articular sites, compromised host),[1,2,34,51] closed multiple diaphysitis (swelling in forearms and legs in compromised children),[2] and tuberculous dactylitis (metacarpal or phalanx). Spina ventosa, a spindle shaped expansion with multiple layers of subperiostial new bone, occurs in the short tubular bones of the hands and feet (Fig. 2B).

If feasible, a biopsy is recommended to establish the diagnosis. The zone of inflammation is large, and diagnostic material is most likely to be found inside the granulomatous focus, or in the synovium adjacent to a cyst.[79] Curettage of the lesion is recommended, however, bone grafting is not necessary.[26,63,70,71,80]

Tuberculous Arthritis

The disease usually begins with seeding of the synovium by bacilli, but may also result from direct penetration of a metaphyseal focus. An effusion develops, and the synovium hypertrophies. Synovial granulation tissue proliferates at the joint periphery, and leads to marginal erosions. This granulation tissue gradually spreads across the joint from peripheral to central, resulting in loss of articular cartilage, and further bony erosions. This progresses to joint destruction, which may be associated with subluxation or dislocation. Ultimately, the joint becomes ankylosed.

The classification suggested by Tuli (Table 1) correlates the clinical and radiographic findings with both the recommended treatment and the expected outcome in patients with articular disease.[71] Chemotherapy is recommended for all patients with active disease. During the early stages of disease, the goal is to obtain or maintain a normal or near normal range of motion. Rest is important, and the patient should be nonweightbearing. Range of motion exercises (active and active-assisted) are started when symptoms allow. Splinting helps to prevent deformity, and traction or serial casting may be used to restore or improve motion and/or alignment before splinting or bracing. Weightbearing (in a splint) is allowed when adequate alignment and motion are achieved, and the disease has been effectively controlled by chemotherapy. For patients presenting in the later stages of disease, the goal is to hold (splint or cast) the joint in a functional position, as ankylosis is expected. For those joints where ankylosis would not be well tolerated (hip and elbow), excisional arthroplasty might be considered. Corrective periarticular osteotomy may be required to reposition those joints that are ankylosed in a suboptimal position. There is also a role for prosthetic reconstruction.[4,11,31,32] Current evidence suggests that there should be a significant disease free interval (ideally

10 years) in between the completion of treatment and prosthetic implantation. Prophylactic chemotherapy for several weeks to months may allow earlier implantation, and chemotherapy can often salvage a prosthetic joint when reactivation of infection has been observed. Unfortunately, the availability of this technology is limited in the regions where tuberculous joint destruction is most likely to be encountered.

SITE SPECIFIC ARTICULAR INVOLVEMENT

Hip

The infection may originate in the synovium, the proximal femur (epiphysis, metaphysis, femoral neck, or trochanteric apophysis), the acetabulum, or the gluteal/iliopsoas bursae.[38,71] Cold abscesses may be palpable in the femoral triangle, the ischiorectal fossa, or the thigh. Sinuses may occur in any of these locations.

The radiographic findings vary considerably, depending on the primary location and degree of involvement, as noted by Shanmugasundaram.[65] A lesion in the acetabular roof ("wandering acetabulum") may result in subluxation, and clinically there will be limb shortening without positioning. True pathologic dislocation may occur as well, which will be associated with both limb shortening and positioning. Protrusio may be associated with lesions in the acetabular floor (Fig. 3A). Coxa magna may be confused with Perthes disease in pediatric patients. Significant joint space narrowing without an osseous focus ("atrophic") may be difficult to differentiate from rheumatoid arthritis (Fig. 3B). Destruction on both sides of the joint may result in irregularity of the femoral head and incongruity ("mortar and pestle").

The treatment principles for joint disease have been outlined previously. In the early stages, a biopsy may be indicated for diagnosis, or for a lack of response to chemotherapy.[7] The role of synovectomy and joint debridement is more controversial. While some authors feel that chemotherapy alone is sufficient,[7] others recommend surgery when significant synovitis is present, but before joint destruction.[4,37,71,83] In the later stages, traction or osteotomy may help realign the extremity, and casting can secure this position until the joint fuses. An alternative for those desiring motion at the expense of stability is excisional arthroplasty, when restoration of motion may take precedence over painless stability to allow cross legged sitting and squatting.[37,70,71,74] For those with a painless ankylosis in a nonfunctional position, osteotomy may be used to realign the limb. Arthrodesis is also an excellent option for those with pain or instability that don't need squatting or cross-legged sitting.

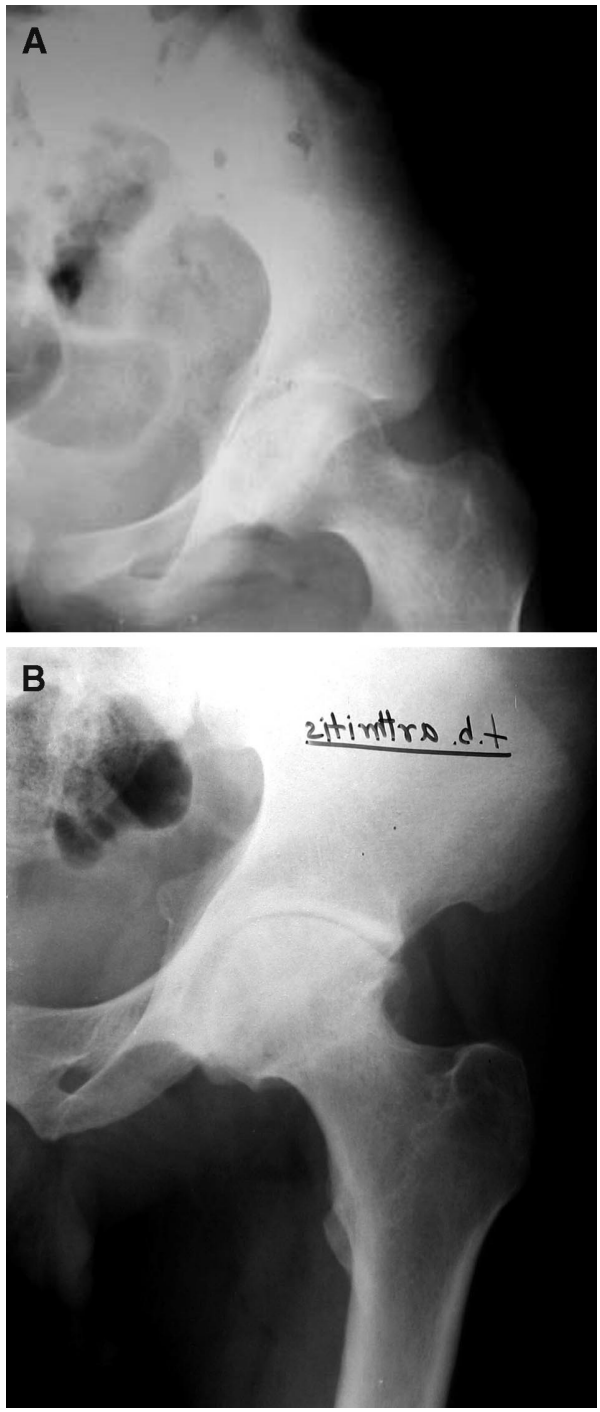

FIG. 3. Tuberculous of the Hip. Morphologic changes in the hip are diverse, and include a "protrusio" type (**A**) and an "atrophic" type (**B**).

Other Joints

The differential diagnosis for tuberculous arthritis of the knee includes rheumatoid arthritis, pigmented villonodular synovitis, hemophilia, and interarticular de-

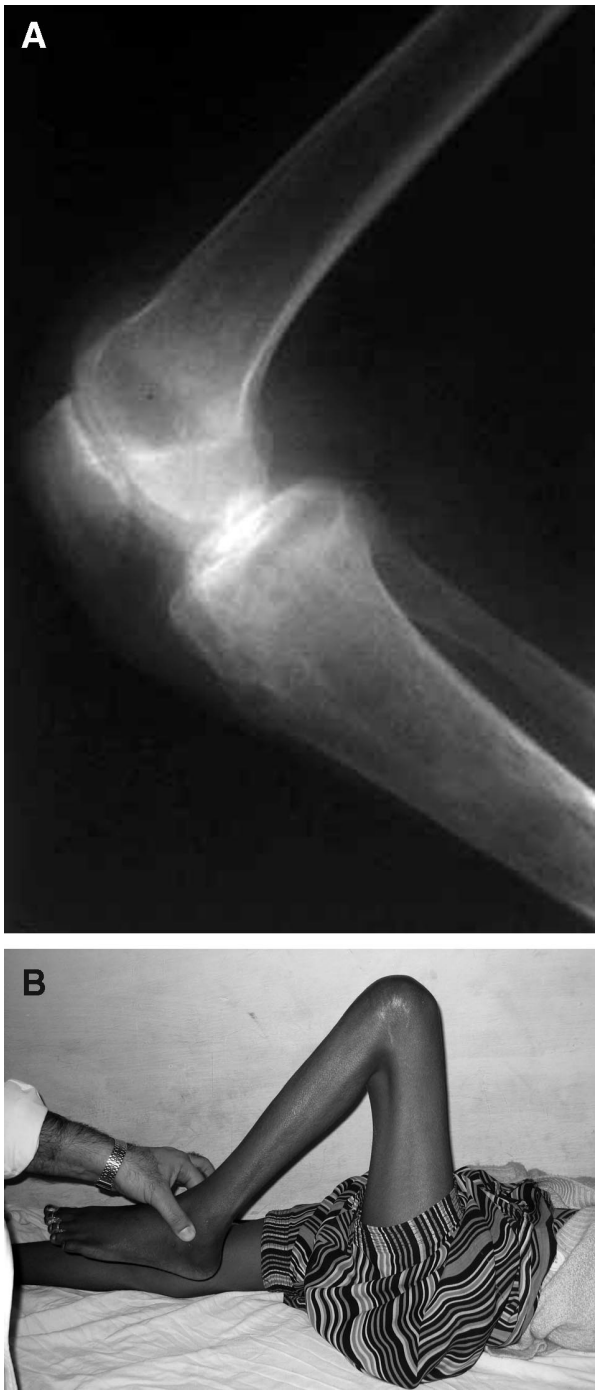

FIG. 4. (A-B) Tuberculous arthritis. In the early stages, there is regional osteopenia and soft tissue swelling, without any bony erosions or joint destruction (**A**). Another patient had a fixed flexion deformity of the knee (**B**) at the time of presentation

rangement (Fig. 4A). Depending on the stage of disease, radiographic findings may include irregularity of the joint space, osteophytes, chondrocalcinosis, and loose bodies.[9] A biopsy is often required to make the diagnosis, and synovectomy may be considered at the same time, although this remains controversial.[22,30,35] During the early stages, traction and/or serial casting may be used to treat flexion contracture (with or without subluxation), and splinting in extension may help to prevent this complication (Fig. 4B).[22,30] For who present at a late stage without deformity, immobilization is recommended until the joint fuses. Osteotomy may be required to reorient the joint, and surgical arthrodesis may be required if spontaneous fusion (or fibrous ankylosis) has not occurred. Prosthetic reconstruction is an option for a subset of patients, as mentioned previously.[11,31]

Tuberculosis of the foot and ankle occurs in less than 5% of cases. The calcaneus is most commonly affected, although any bone or joint may become involved.[10,48,71] Local spread of disease may result in multiple sites of involvement.[48,71] Cystic lesions with a well defined border an no sequestrae are most common.[48] "Rheumatoid" lesions have osteopenia associated with a diminution in joint space, and occur most frequently in the midfoot. Subperiostial scalloping may be seen on one or both ("kissing lesions") sides of the joint. Needle aspiration is an alternative to open biopsy,[10] and surgical intervention may be indicated to arrest the local spread of disease.[71] Surgery may be required to establish the diagnosis, to debride infected foci, and/or to stabilize joints.

Upper extremity involvement is uncommon.[71] Disease in the shoulder usually occurs in adults, and is commonly a dry, atrophic form (sicca arthritis). The joint tends to become fixed in adduction, and arthrodesis may help to treat pain, stiffness, or instability. At the elbow, excisional arthroplasty may be preferable to arthrodesis for end stage disease. Involvement of the wrist is rare. Anterior dislocation of the carpus may be observed, and secondary involvement of the flexor tendon sheaths has been described. Splinting in dorsiflexion may be helpful, and occasionally arthrodesis is required.

TUBERCULOUS SPONDYLITIS

Approximately 50% of patients with osteoarticular tuberculosis will have spinal involvement. As modern chemotherapeutic protocols are highly effective in treating the disease, a major focus has been to prevent or treat kyphotic deformities.

Although the thoracic and thoracolumbar spine are involved most commonly, the disease may be seen in any region of the spine. Also, skipped lesions may occur rarely. The most common is presentation involves destruction adjacent to the endplates of two (or more) vertebral bodies (paradiscal type) (Fig. 5). The process

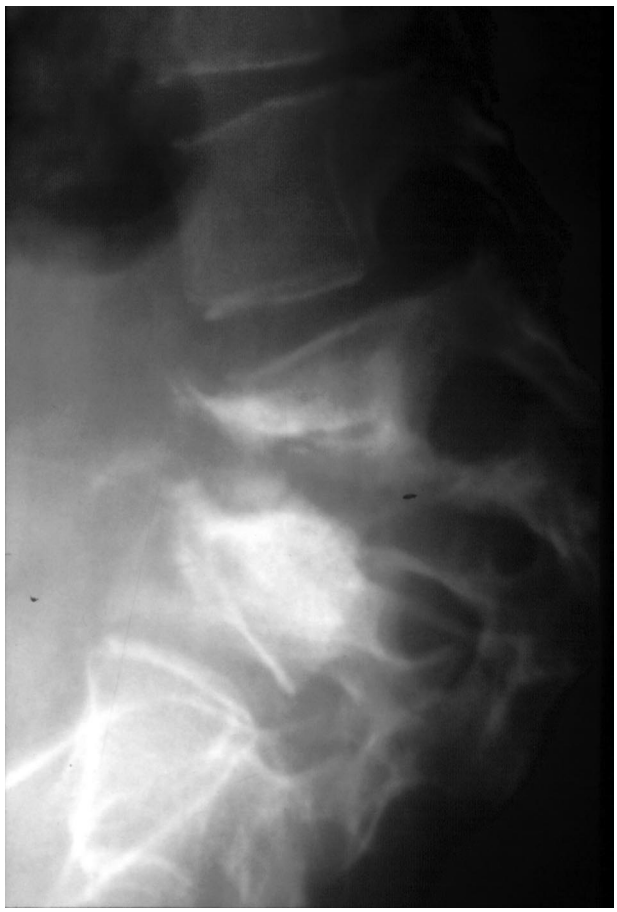

FIG. 5. Spinal Tuberculosis. This case involving the lumbar spine demonstrates involvement of three vertebrae anteriorly, and the bodies of L2 and L3 have collapsed and become fused.

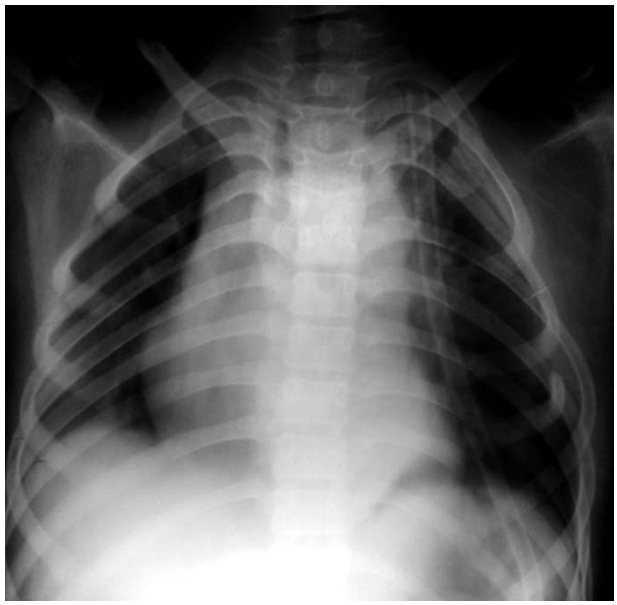

FIG. 6. Spinal Abscesses. Abscesses are commonly seen on the chest radiograph, appearing as an elongated density along the spine. The involved levels may be identified by a loss of disc space height, widening of the body, and collapse if present. Chronic abscesses of the spine or other locations may become calcified over time.

begins with disc space narrowing, and the bony changes often do not appear for 3 to 5 months. Abscesses may track along the anterior and lateral margins, giving rise to vertebral scalloping ("aneurysmal phenomenon"). Abscesses may be seen on both chest and spinal radiographs (Fig. 6). Abscesses below the diaphragm typically track along the psoas sheath, resulting in an asymmetry of the psoas shadow. Atypical radiographic findings include involvement of the posterior elements, circumferential involvement, lateral vertebral translation, involvement of a single vertebra or multiple vertebrae, and the spinal tumor syndrome.[3,54,58,68]

The differential diagnosis for spinal tuberculosis is large, especially in regions where the disease is less common. In addition to pyogenic vertebral osteomyelitis, other infections that may give a similar radiographic appearance include *Salmonella typhi*, *Brucella*, fungi (actinomysosis, blastomyscosis), and syphilis. Both benign (hemangioma, giant cell tumor, aneurysmal bone cyst, Histiocytosis X) and malignant tumors (Ewing's sarcoma, osteosarcoma, multiple myeloma, metastases) may also be included in the differential. Radiographic features that support the diagnosis of tuberculosis include multiple levels of involvement, relative sparing of the intervertebral disc, a large paravertebral abscess, subligamentous spread, multicentric involvement, and heterogeneous signal with rim enhancement on magnetic resonance imaging (MRI).[14] Even under the best of circumstances, a tissue diagnosis is difficult to achieve. Chen et al. found that on biopsy, the smear was positive in only 15%, and that histology was "typical" in 60% and "compatible" in 36%.[8]

Neurologic dysfunction is a dreaded complication of spinal tuberculosis. In general, the prognosis for recovery is good if the neurologic dysfunction develops gradually and is of short duration. A poor prognosis is encountered in patients with a complete paraplegia, flaccid paralysis, rapid development, longer duration of symptoms, and late onset of disease ("healed disease"). Spinal cord dysfunction may occur either during the "active" and "healed" phases of disease, and both the etiology and the prognosis differ considerably. The causes of neurologic compromise during the active phase are inflammatory edema, extradural compression from posterior extension of an abscess (pus, caseous material, granulation tissue, sequestrae), or an internal gibbus

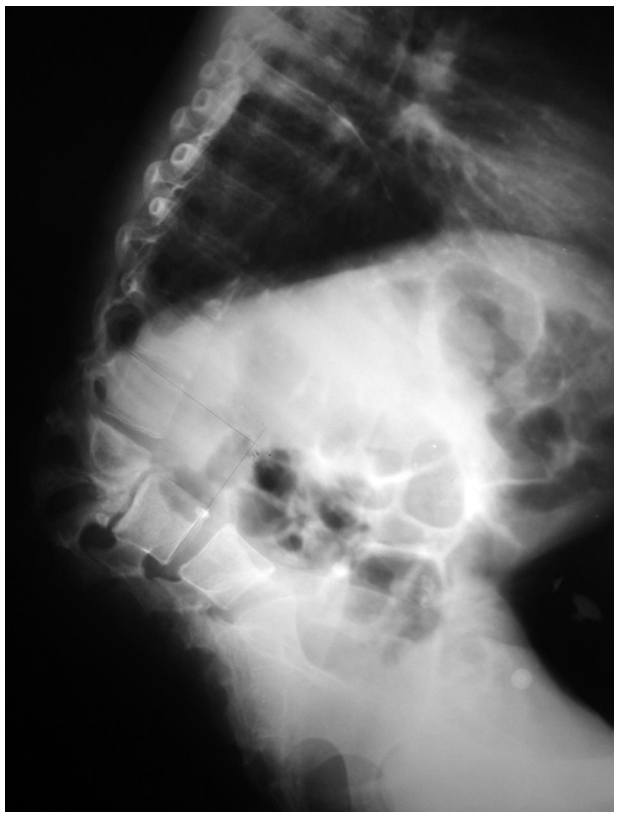

FIG. 7. An example of "healed" disease, with fusion of the L1 through L3 vertebral bodies. Although a significant kyphosis was observed in this teenager, he was asymptomatic and neurologically normal.

following collapse or malalignment of the involved vertebrae.[20] Although the posterior longitudinal ligament usually protects the dura, direct invasion of the dura has been documented in a minority of cases.[18,20] Rarely, there may be neurologic compromise without bony changes. A "spinal tumor syndrome" may result from tubercular granulomas in an extradural, intradural, or intramedullary location. Either an MRI or a myelogram will be necessary to make this diagnosis. Spinal cord infarction results in a sudden and irreversible paraplegia, and is fortunately rare. Neurologic compromise associated with "healed disease" (occurring more than 2 years after disease onset) may result from spinal stenosis, direct compression from an internal gibbus deformity, and constriction by peridural fibrosis (Fig. 7).[20] With adequate treatment, the prognosis for neurologic recovery is generally good for patients with active disease, and guarded for those with healed disease. MRI findings associated with a poor prognosis include myelomalacia, thinning of the spinal cord, and the presence of a syrinx.[28]

Treatment begins with chemotherapy and general measures to improve the patient's physiologic state. Studies undertaken by the Medical Research Council of Great Britain found that outpatient chemotherapy is highly effective for "uncomplicated" spinal tuberculosis, and that the results were not improved by bedrest, by the use of a spinal orthosis, or by surgical debridement.[39–47] If adequate resources were available, then surgical decompression and arthrodesis (Hong Kong procedure) resulted in faster healing and less deformity. It should be noted that exclusion criteria included patients with extraspinal disease, paraparesis of a degree that walking across a room was not possible, and recurrence of disease. Pattisson et al. studied 89 patients with neurologic deficits (active disease) treated by chemotherapy alone, and found that at latest follow up, 72% were neurologically normal, and 84% could ambulate with an assistive device.[56] The duration of chemotherapy remains controversial for spinal disease. Traditionally, 18 months of chemotherapy has been recommended. Recently, Parthasarathy et al. have suggested that the duration of therapy may be reduced to 9 months.[55]

The role of surgery varies throughout different regions of the world, and both the indications for surgery and the specific procedures recommended remain somewhat controversial. To an extent, recommendations are based on the resources available locally, and the presence of surgeons with specialized training. The procedures are technically demanding, and intensive medical management is required during the perioperative period. The surgical treatment philosophy varies from routine decompression and arthrodesis (Hong Kong and others), to the "middle path" developed by Tuli in India, to chemotherapy alone when the resources for spinal surgery are unavailable. If Pattison's figures of 72% recovery with chemotherapy alone are to be generalized then surgery is needed in just 18% of these patients and criteria to identify them with sufficient post-test probability need to be established.

The "middle path" treatment approach reserves surgery for the treatment of complications of the disease.[27,70–73,75] Patients are started on chemotherapy, and initially are managed with bedrest. Both the erythrocyte sedimentation rate and spinal radiographs are monitored at 3 to 6 month intervals. Patients are mobilized in a brace once their symptoms have subsided, and bracing is continued for a total of 18 to 24 months. Subcutaneous abscesses are aspirated, and 1 g of streptomycin may be instilled locally. Sinus tracts are excised if they remain after 12 weeks of chemotherapy. Surgical treatment is suggested for an increase in size of a paravertebral abscess despite adequate chemotherapy, involvement of the posterior elements, lack of clinical response after 3 to

6 months of chemotherapy (neurologically normal), lack of neurologic recovery or progression of neurologic deficits after 3 to 4 weeks of chemotherapy, recurrence of disease, mechanical instability, or an uncertain diagnosis. Overall, surgery is recommended for approximately 5% of uncomplicated cases, and 60% of those with neurologic deficits.

According to Jain et al., the indications for surgery may include *clinical factors* (neural arch involvement, recurrent paraplegia, and massive retropharyngeal abscess causing difficulties with ventilation or swallowing), treatment factors (persistent or progressive deficit while following an adequate course of conservative treatment), *imaging factors* including panvertebral involvement [scoliosis or severe kyphosis on plain films, global destruction on compute tomography (CT) or MRI] or extradural compression (circumferential cord compression from granulation tissue on MRI), and *patient factors* (painful spasm or nerve root compression).[28]

While 80% of patients will have some localized kyphosis, only 3% to 5% progress to greater than 60° (Fig. 8).[59] Progression may occur during both the active phase and after healing.[59–61] Risk factors include age (children), thoracic involvement, multiple levels of involvement, and greater initial loss of vertebral height. Radiographic "at risk" factors include dislocation of the facets, retropulsion of diseased fragments, lateral translation of a vertebra, and toppling of a vertebra.[61] Thus, prophylactic stabilization (with or without decompression) may be indicated for a subset of patients felt to be at high risk for the development of a significant kyphotic deformity. The treatment of deformity (and or paraplegia) associated with "healed disease" is challenging and fraught with complications.[75] It should be noted that improvement in kyphosis may be observed in children, as the anterior vertebral growth centers may escape damage by the infection.[61,62,64]

As the pathology is usually anterior, the procedure most commonly used has been an anterior decompression and arthrodesis, as popularized in Hong Kong.[6,18–21,25,29,36,78,82] A structural graft is essential to support the anterior column of the spine and to resist the progression of kyphosis. This approach may be technically difficult in the presence of severe kyphosis, in which case a lateral extrapleural approach may enhance visualization at the apex. Graft complications are more frequent when more than 2 disc spaces are involved, and include subsidence, resorption, fracture, and loss of position (Fig. 9).[29,62] Progression of deformity may also be observed following a successful anterior arthrodesis, although the frequency and magnitude vary within the literature. Whereas Upadhyay et al. concluded that progression (posterior overgrowth) does not occur in children,[78] Rajasekaran observed an increase in kyphosis of more than 20° in 22%.[62]

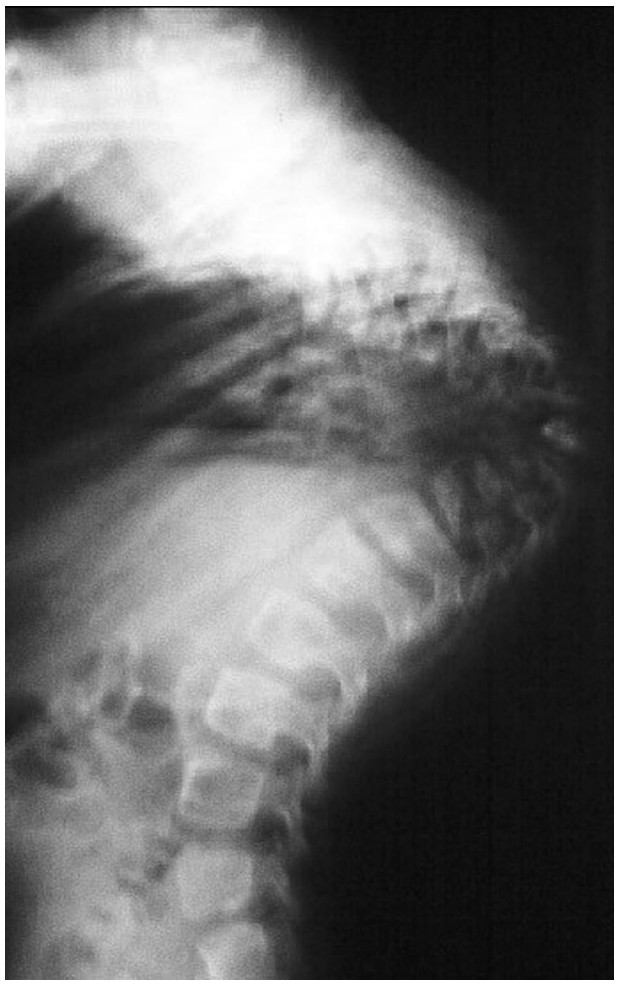

FIG. 8. A severe kyphosis develops in a minority of cases. This patient remained asymptomatic, as the kyphosis developed over several years. There remains a concern that he will develop neurologic dysfunction in the future. Risk factors include children with multiple levels of involvement in the thoracic spine, and a greater degree of vertebral collapse initially. Prophylactic stabilization of the spine should be considered in such high risk cases, if the resources are available.

Other approaches include a posterior spinal fusion,[17] an anterior and posterior spinal fusion, a posterior spinal fusion followed by an anterior spinal fusion (same day or staged), costotransversectomy, and a lateral extrapleural approach. Both an anterior and posterior arthrodesis is recommended to treat the instability associated with circumferential disease. In addition, for those with greater than 3 levels of involvement, this approach may be the only method to reliably prevent the progression of kyphosis. Performing an instrumented posterior spinal fusion as the first stage, followed by a second stage anterior decompression and arthrodesis, may provide

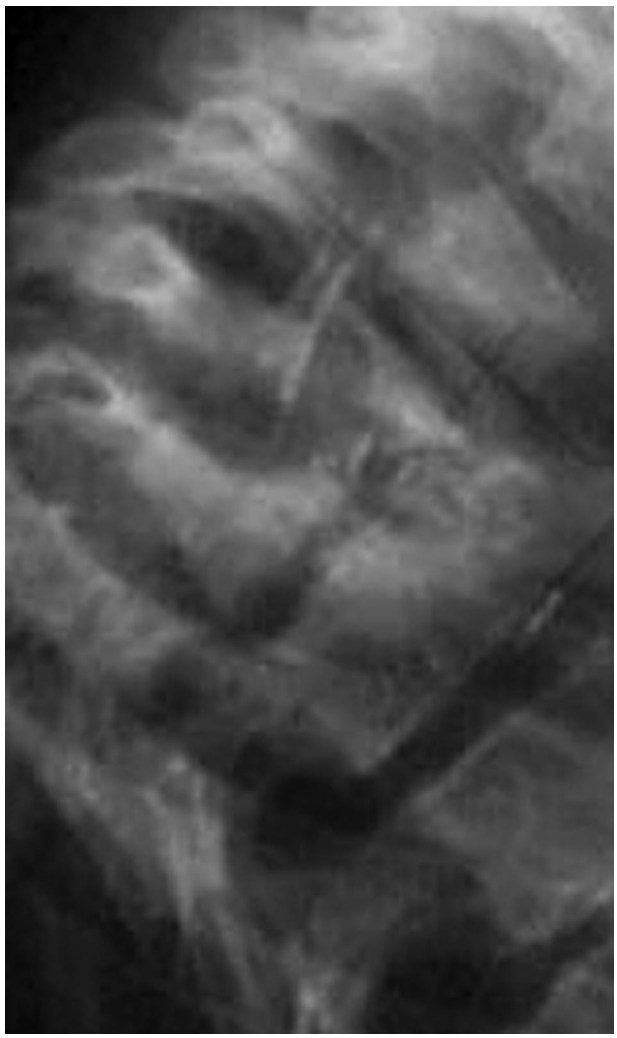

FIG. 9. Graft complications are frequent when more than 2 disc spaces are spanned. In this example, reactivation of disease (associated with noncompliance with chemotherapy) resulted in graft resorption, fracture, and persistent deformity.

protection for the anterior graft in situations where a longer segment must be spanned, and graft complications are likely.[17,50,59] This approach is recommended when more than 3 levels are involved in the disease process.[64,62] The posterior procedure should include 2 to 3 levels above and below the apex of the kyphosis. Costotransversectomy facilitates evacuation of a liquid abscess, but the exposure is insufficient for decompression and bone grafting. In this procedure, the medial portion of the rib and the underlying transverse process are removed, and an extrapleural dissection leads to the abscess. The lateral extrapleural approach is more versatile. Following removal of the medial portion of the rib and the transverse process, the pedicle is removed to allow greater access to the vertebral body and spinal cord. Typically, two to 3 levels must be exposed to facilitate debridement and bone grafting. The intercostal nerve is used as a guide to the foramen and spinal cord at each level to be exposed. A noninstrumented posterior spinal fusion may be performed through the same approach.[13] Finally, a laminectomy is indicated in the rare case in which isolated involvement of the posterior elements is observed.

Sources for bone graft may include rib, iliac crest, and fibula. The limited information available suggests that allografts may also be used safely to support the anterior column of the spine.[15,16] Instrumentation may be used in the presence of mycobacterial infection,[52] and although posterior instrumentation has been used most frequently, the successful use of anterior implants has been reported as well.[16,84]

Cervical spinal involvement is uncommon, and patients typically present with pain, stiffness, and torticollis.[12,24,27,36,71,72] Large abscesses may result in hoarseness, stridor, and dysphagia. Cervical lymphadenopathy, sinuses, and neurologic involvement are all commonly observed. Atlanto-axial involvement may result in instability at this articulation. Noncontiguous involvement may be seen, and involvement of more than two vertebrae is not uncommon in the mid-cervical spine. The lateral radiograph usually demonstrates widening of the retropharyngeal space in the presence of an abscess. In addition to chemotherapy, treatment recommendations have varied from the more conservative "middle path" protocol[27,71,72] to routine decompression and arthrodesis.[12,24,36] A uniform indication for surgery is when an abscess results in dysphagia, stridor, or difficulty with respiration. In the "middle path" approach, patients are started on chemotherapy and placed on bedrest with or without cervical traction, and an orthosis is occasionally recommended. The general indications for surgical decompression and arthrodesis have been outlined previously. Options for decompression include the transoral route, or an anterior approach along the anterior border of the sternomastoid muscle. Arthrodesis maybe accomplished either anteriorly or posteriorly.

The lumbar spine is also involved less frequently than the thoracic or thoracolumbar spine.[49,57] Patients often present with pain, and neurologic dysfunction is uncommon. Kyphotic deformities are seen with some frequency. Chemotherapy is effective, and the indications for surgery remain unclear. While Moon et al. report a relatively benign course in 56 adults treated by chemotherapy alone,[49] Pun et al. found late pain and degenerative changes in more than 50% of patients, with significant kyphosis in 14 of 26 patients.[57] Compensatory lordosis in

the upper lumbar and thoracic spine may be observed. Disease at the L5-S1 level is more difficult to address surgically, especially if grafting is deemed necessary.

SUMMARY

Osteoarticular tuberculosis may be seen with some frequency by health care professionals working in various regions of the world, particularly in South and Southeast Asia. Chemotherapy is extremely effective as long as the appropriate regimen is prescribed, and patient compliance is ensured. Surgical intervention is most commonly required to establish the diagnosis, and to treat the musculoskeletal complications of the disease, especially in cases with delayed presentation. Outcomes may be maximized through early detection and treatment, although adequate results can still be achieved with salvage procedures in patients presenting with late stages of disease.

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