INTRODUCTION:
The detection or differential diagnosis of spinal infections is sometimes difficult despite the availability of advanced diagnostic technology. Although Jung et al concluded that MRI is accurate for differentiating tuberculous spondylitis from pyogenic spondylitis, ambiguous cases are often encountered in daily clinical practice. Moreover, there are often patients who are unable to undergo an immediate biopsy or surgery. Recently, positron emission tomography (PET) with fluorodeoxyglucose (FDG) has been used increasingly to detect suspected infections. Fluorine-18 (18F) FDG PET has demonstrated high sensitivity and specificity for detecting and identifying the processes of inflammatory activity in spondylitis. Gratzi et al suggested that FDG hybrid PET can help to correctly identify those patients with vertebral osteomyelitis. It assists in differentiating between mild infections and degenerative changes, detects additional manifestations outside the spine in a substantial number of patients, and shows a good correlation with the histological severity of the infection. In particular, a combined PET/CT study can provide a synergistic combination of PET and CT, which is potentially more valuable than performing the two examinations separately.

To our knowledge, there is little clinical experience in the field of PET/CT imaging for distinguishing between pyogenic and tuberculous infections. Therefore, this study evaluated the usefulness of 18F-FDG PET/CT for differentiating between tuberculous and pyogenic spondylitis and compared it with the diagnostic performance of MRI.

METHODS:
Patients. Between January 2005 and March 2007, 22 consecutive patients (7 male, 15 female; age range, 19-81 years; mean 58 years), who were diagnosed clinically and radiographically with infectious spondylitis, were enrolled in this study. All patients were confirmed by open surgery to have either tuberculous (11 patients) or pyogenic spondylitis (11 patients). None of the patients in this study had previously undergone spinal surgery in the region of concern nor did they have any hardware in place. In addition, none of the patients had traumatic compression fractures or spinal malignancies. The patients underwent contrast-enhanced MR imaging of the spine for a detailed evaluation of possible infectious spondylitis within 7 days before undergoing PET/CT. Only those patients in whom MRI strongly suggested infectious spondylitis underwent a PET/CT scan. All except for four patients underwent dual–time point FDG PET/CT scans. All imaging studies were performed within 7 days before surgery. In addition, C-reactive protein (CRP) level was measured at the time of PET/CT scanning to determine the correlation with disease activity. The CRP values of all patients were compared with the maximum SUVs of the early phase. The PET/CT and MRI results were verified by a culture of a sample obtained surgically or by the pathology findings. No treatment was administered between the imaging studies and surgery. This prospectively comparative study was approved by the institutional review board and written, informed consent was obtained from all patients.

Evaluation of MR images. The spine MR images contained the T1-, T2-weighted and contrast–enhanced, axial and sagittal plane images. All MR images were evaluated both independently and in consensus by two experienced radiologists specializing in MR imaging of the musculoskeletal system. The radiologists were blinded to the patients’ clinic history, laboratory and pathologic results. All MR images showed findings of infectious spondylitis. The radiologists attempted to differentiate between tuberculous and pyogenic spondylitis according to the criteria of published studies. The following findings were evaluated on MRI with reference of the study of Jung et al: the presence or absence and abnormal paraspinous signal and its margin; abscess wall; the presence or absence of a psoas abscess; the extent of subligamentous spread (more or less than three vertebral); and the number of vertebra involved (more or less than two). Cases of well-defined paraspinous lesions were scored 1 for each of the following: a smooth and thin abscess wall, subligamentous spread over more than three vertebral, involvement more than two vertebral, thoracic spine involvement, and the presence of psoas abscess. When MR images were not satisfied with above findings, we scored 0 for each parameter. Therefore total MR score is 6, if the score of each parameter is 1 in one patient. Above parameters are more often findings in tuberculous spondylitis. Therefore according to the law of majority, the radiologists diagnosed tuberculous when the MRI scores were ≥ 4 and pyogenic spondylitis when < 3. When the score was 3, we diagnosed tuberculous spondylitis if findings of a thin and smooth abscess wall and large or multiple psoas abscesses are seen on MRI because above findings are the most significant in tuberculous spondylitis according to Jung et al. These MRI results were also compared with the mean values of the maximum SUVs of early-phase PET/CT.

Analysis of PET/CT images. All PET/CT studies were reviewed by two nuclear medicine physicians who had 11 and 4 years experience each with combined PET/CT evaluation. The physicians were blinded to the clinical and pathology results. The PET/CT data sets of the early and delayed scans were analyzed semiquantitatively using the standardized uptake value (SUV). The maximum and mean SUVs of each early and delayed image were obtained by selecting a small region of interest (ROI). Spherical ROIs were placed over the lesions that were visible on the PET images. ROIs were placed in the same area on the image selected for both the early and delayed scans. The maximal SUVs (SUVmax) were calculated by manually drawing a region of interest (ROI) over the most intense slice of the primary lesion visible on the PET/CT images. The mean SUV (SUVmean) was also obtained by drawing an ROI whose borders were defined by an automatic isocountour set to 75% of the SUVmax within the ROI because this allowed good reproducibility between subjects. The number of SUV measurement sites, including bone and soft tissue areas in the 11 pyogenic spondylitis patients and 11 tuberculous spondylitis patients was 30 and 38, respectively.

Results: Among the twenty-two study patients, eleven patients each were diagnosed with tuberculous spondylitis and pyogenic spondylitis after surgery. The reviewers identified tuberculous spondylitis on MRI with sensitivity, specificity, and positive predictive values of 90 %, 100 %, and 100 %, respectively. For pyogenic spondylitis, the corresponding values were 100 %, 90 %, and 92 % on MRI. There was a significant difference in the maximum SUVs of the early phase of PET/CT between tuberculous and pyogenic spondylitis (p = 0.028). On the other hand, there was no significant difference in the maximum SUVs in the delayed images, the mean SUVs of each early and delayed image, and each difference in the maximum and mean SUVs between the early and delayed phase between tuberculous and pyogenic spondylitis (p > 0.05). Therefore, it was not necessary to obtain delayed scans on FDG PET/CT scan to differentiate tuberculous from pyogenic spondylitis because only the maximum SUV of the early scanning was meaningful. According to ROC curve analysis, an SUV > 3.8 might be used as a threshold to differentiate tuberculous spondylitis from pyogenic spondylitis (AUC (area under the ROC curve), 0.651; 95% CI (confidence interval), 0.512 to 0.773; S.E. (standard error), 0.0778; p = 0.05). The sensitivity and specificity were 46 % and 81 %, respectively. A direct comparison of the diagnostic performance of MRI and PET/CT scan revealed MRI to be superior to PET/CT for distinguishing between tuberculous and pyogenic spondylitis (difference between area, 0.240; S.E., 0.119; 95% CI, 0.0072 to 0.473; p = 0.043). In addition, A comparison of maximum SUVs of the early phase with the CRP values revealed a correlation coefficient of 0.581 (p = 0.016).

CONCLUSION: The maximum SUVs of the early phase on 18F-FDG PET/CT scanning were statistically significant in differentiating tuberculous from pyogenic spondylitis. In addition, there was a significantly correlation with the CRP values. Overall, these results suggest that 18F-FDG PET/CT may be a complementary method to MRI for distinguishing between pyogenic and tuberculous spondylitis as well as for determining the activity of infectious spondylitis.