MRI and PET/CT of patients with bone metastases from breast carcinoma

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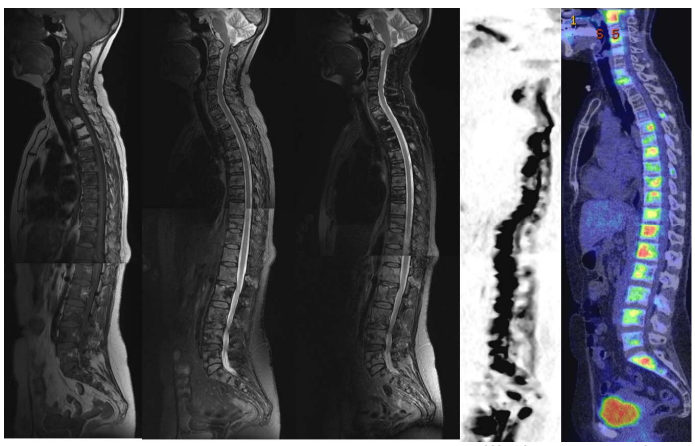
Introduction and purpose

Magnetic resonance imaging (MRI) as well as 18-fluoro-deoxy-glucose positron emission tomography / computed tomography (PET/CT) are used for the detection and follow-up of bone metastases. This prospective study aims to determine whether 3T MRI can diagnose bone metastases from breast cancer as effectively as PET/CT (gold standard). A new diffusion weighted whole body sequence was tested together with MRI standard T1, STIR and T2-fat-saturated sequences.
The whole body diffusion scan was evaluated with regard to potential use as a stand alone sequence or alternatively as a supplement to standard MRI.

Materials and Methods

Breast cancer patients with suspected or known bone metastases were recruited from the Outpatient Clinic at the Department of Oncology. Patients were included as they presented themselves clinically, with no regard to previous treatment regimens. So far, 13 patients have undergone both MRI and PET/CT scans within a maximum interval of ten 10 working days.
A GE Discovery VCT scanner was used for PET/CT examinations: 5 mm slice thickness, 0 mm spacing, from skull base to mid-thigh.
MRI was performed on a 3Tesla scanner (GE Signa HDx) with the following protocol:
Spine: Sagittal T1 fast spin echo, FOV 46cm, 2 NEX, BW 42kHz, TR 800ms,TE minimumFull, freq 512, Phase 256, slice thickness/spacing 4.0/0.4mm, echo train length 3. Sagittal STIR: same parameters as "Sagittal T1" except TR 4500ms, TI 170ms, TE42ms, Echo train length 7.
Sagittal T2 FS, fast spin echo, Fat Saturation TR3000, TE 102ms, echo train length 19, 3 NEX, same resolution as Sagittal T1.
Pelvis: Coronal STIR: IR-fast spin echo, FOV 42cm, 2 NEX, TR 4000ms, TI 170ms, TE 42ms, echo train length 7, BW 42kHz, freq 384, phase 256, slice thickness/spacing 8.0/1.0mm. Coronal T1: same parameters as Coronal STIR except TR 600ms, TE minimumFull, echo train length 3.
Diffusion: Axial, body coil, dual spin echo EPI DIFF, FOV 44cm, 4 NEX, BW 250kHz , TR 2900ms TE minimum, freq 80 phase 128 slice thickness/spacing 5.0/0.0mm, B-value 600, Diffusion directions 3. Stations: 4-5 to cover the whole spine and pelvis.
PET/CT examinations were reviewed by two radiologists, and their consensus on metastases in 27 predefined locations was recorded. The 27 locations include each of the vertebral bodies (24), the left (1) and right (1) pelvic bone, and the sacral bone (1). The project was approved by the local ethics committee, and informed written consent was obtained from all patients before the first scanning.



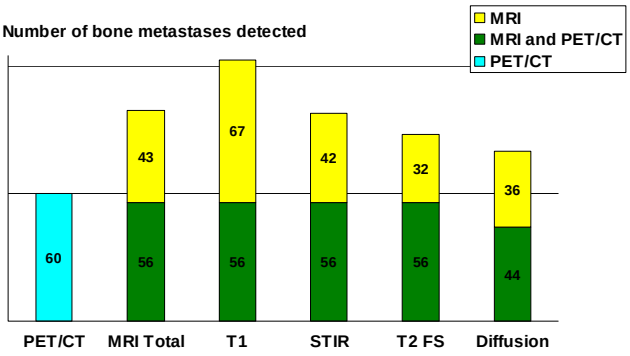


Figure 1: Number of bone metastases on MRI compared with PET/CT.

Figure 2: MRI T1, STIR, T2-FS, diffusion and PET/CT fusion images of a 72-year-old female, previously operated for breast cancer, now with multiple metastases to the spine (black on the inverted diffusion image).

Results

Metastases detected with PET/CT and MRI in the 27 locations in the first 13 patients are shown in figure 1. PET/CT (blue) detected 60 active metastases. Of these MRI detected 56 (green). "MRI Total" represents metastases detected on T1 plus either STIR or T2 (or both). "MRI Total" detected 43 additional metastases (yellow). PET/CT detected four active metastases, not detected on any MRI sequence. Diffusion detected 70 metastases, 44 of which were recognised on PET/CT.

Discussion

PET/CT was selected as the gold standard because of the physiological glucose uptake in active tumours. Chemotherapy treatment within 14 days of PET/CT may reduce the 18FDG-glucose uptake and hence decrease the number of active metastases detected, compared with MRI. Furthermore, the post treatment residual scars, which are glucose inactive on PET/CT, cannot be differentiated from active metastases on the T1-weighted sequence of the MRI alone. This may explain the larger number of metastases detected by MRI as compared with PET/CT.
Four metastases were detected only with PET/CT. One patient had received experimental localized hydro-ablation therapy, and her count of metastases equalled nine on both modalities. Six of the locations were identical on both modalities; three of the locations were not. In another patient all lesions seen on PET/CT were also detected on MRI, except one located in the right transverse process of a fourth thoracic vertebra. Retrospectively, this PET/CT detected metastasis in the fourth thoracic vertebra had been classified on MRI as a "non-metastatic lesion" on the T1 and T2 sequences.
Distortion artefacts were present on the diffusion sequence, especially around the shoulders/neck region, sometimes preventing exact localisation of metastases. Such metastases were noted on the sequence but not included in the comparison of locations with PET/CT. In all patients, we have chosen not to include metastases on the diffusion sequence above the fourth thoracic vertebra for the clinical comparison, because of these distortions; hence the lower number of metastases detected on the diffusion sequence. Haemangiomas and oedema could not be differentiated from active metastases on the diffusion sequence alone.

Conclusion

3T MRI including diffusion sequence shows a larger number of bone metastases from breast cancer than PET/CT. Treatment response may explain this difference, where PET/CT probably shows active metastases. The exact location of metastases could not be determined on the diffusion weighted sequence alone, especially around the neck/shoulder region.