Computer-aided detection of skeletal metastases in MRI STIR imaging of the spine

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Purpose

To assess feasibility of computer aided detection (CAD) of skeletal metastases in MRI STIR imaging of the spine.

Methods

The patient population included 42 patients (25 female, 17 male, mean age 60 years, range 25-81 years) with different histologically clarified primary tumors examined with MRI of the spine for staging and follow-up of known skeletal metastases. The gold standard was constituted by histology and/or clinical-radiological follow up within at least 6 months.

MRI was performed at 1.5 Tesla on a 32-channel scanner (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) with the use of parallel acquisition techniques (PAT). All patients underwent short tau inversion recovery-(STIR)-imaging (TR 5700/TE 59, matrix 384- of the complete spine in sagittal orientation. Using a PAT-factor of 2 scan time was 7.36 min with a resolution of 1.0 x 1.0 x 3.0 mm. The data was split into training and test sets. Training set included 21 patients, of which 12 had osteolytic spine metastases (13 focal, 6 diffuse and 10 multifocal lesions). Test set included 21 patients, of which 9 had osteolytic spine metastases (12 focal, 6 diffuse and 8 multifocal lesions). Each spine section (cervical, thoracic and lumbar) with diffuse or multifocal infiltration was counted as one lesion.

The fully automatic metastases detection algorithm (research prototype) included vertebrae segmentation, primary lesion detection and false positive reduction steps. First, intensity inhomogeneity correction was applied. Then, spinal cord was modeled as a global 4^{th}-order 3D-polynomial using random sample consensus (RANSAC) algorithm with least-squares-based fitting refinement. Each vertebra body was modeled as a curved elliptical cylinder section adjacent to the front edge of the detected spinal cord. Primary lesion candidate detection inside segmented vertebrae was performed using adaptive intensity thresholds. Multiple features characterizing intensity, texture, volume, shape and location of candidate lesions were extracted from 3D image data. Finally, a linear classifier trained on the training set was applied to reduce the number of false positive (FP) detections by addressing the multiple instance learning problem. The classifier was constructed by taking into account the fact that a lesion may associate with several detections and if any of them is correctly classified, the lesion is identified.

Results

The training and test set sensitivity was 82.76% and 84.61%, respectively, with 5 false positive detections per patient. The CAD software missed 3 focal lesions in the training set and 3 focal lesions in the test set. One diffuse lesion (spine section) was missed in one patient from the test set and one multifocal and one diffuse lesion (spine section) were missed in two patients from the training set. However, other lesions or infiltrated spine sections were successfully detected in the same patients.

Conclusion

Spine metastases CAD showed high standalone sensitivity at a relatively low FP rate. While this study confirmed CAD feasibility, the next step is to incorporate additional features from T1-weighted SE-sequences. Furthermore, the additive benefits of CAD as a second reader should be investigated.

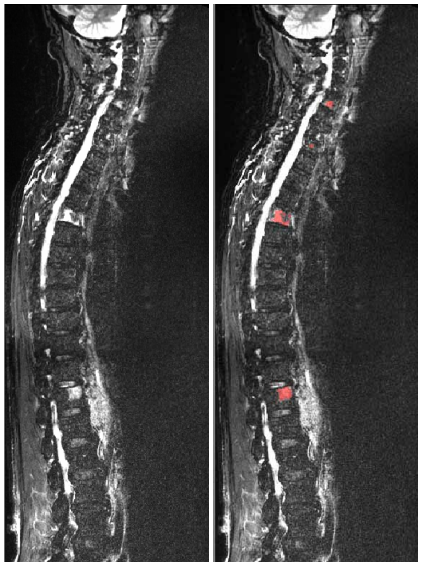

Figure1. Left: original sagittal STIR image of the spine. Right: focal lesions detected by CAD are highlighted in red

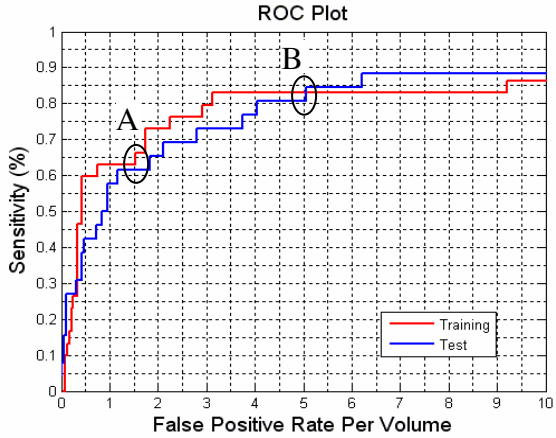

Figure 2. ROC curves for training and test sets.
A. Sensitivity at 1.5 FPs per patient: training – 66.32%, test - 61.61%
B. Sensitivity at 5.0 FPs per patient: training – 82.76%, test - 84.61%