Positional Variations of the Breast in Supine Position between Two MR Scans

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INTRODUCTION

Since dynamic contrast enhanced MRI of breast cancer correlates well with histological findings, it is well suited for surgical planning and pre-surgical tumor localization. However, MRI is typically performed in a prone position and the breast configuration is significantly different than in the surgical setting where the patient is supine. In consequence, MRI is currently not used to guide surgery.

Our hypothesis is that scanning the breast with supine positioning of the patient will allow us to register the acquired MR images to the later similar situation in the operating room (OR). Since the tumour location will already be known from previous diagnostic scans, a unilateral scan will be sufficient. For the image registration, MR markers will be placed on the patient's breast during the MR scan. Later in the OR, their pen-marked positions will be registered using an optical tracking system.

The specific goal of this study is to estimate the positional variations which are expected between the preoperative MR scan and the OR.

MATERIALS AND METHODS

A home-build receive phased array coil (2 elements, size of each element: 10.2×20.3cm^2) and fixture was used, which permitted an easy placement of a patient in supine position on the standard bed of a whole body 1.5T MR scanner (GE Signa Excite). All images were acquired unilaterally using a fast 3D spoiled gradient echo (fast 3D SPGR) sequence with the following parameters: T_R=6.432ms, T_E=4.2ms, α=30°, matrix size: 256×256×32, FOV: 200×200×70mm^3 and 1 NEX. A slightly tipped coronal plane position was chosen with a left-right phase-encoding direction ensuring a full coverage of the entire breast. The imaging sequence was modified to allow compensation for respiratory motion according to the zonal motion-adapted acquisition and reordering technique (ZMART) [1], which is a combination of k-space reordering and gating. The actual position in the respiratory cycle was tracked using a respiratory belt. The gating limit was set to 75% of the maximal displacement between expiration and inspiration, which increased the normal scan time from 54s to approximately 80s (depending on the actual breathing of the patient).

Nine small MR markers (contrast agent filled spheres with a diameter of 4mm) were uniformly placed over the breast of a volunteer and held in position by surgical tape.

To assess the expected changes in the position of the breast between the pre-operative MR scan and the OR, two sets of 5 MR scans were acquired. After the acquisition of the first set, the volunteer was removed from the magnet and then repositioned for the second set of scans.

After the scans, the positions of the markers were determined within the entire 3D volume. Then the data of the two sets were matched by minimizing the distances of marker positions between the two sets allowing all the degrees of freedom of rigid body motion (translation and rotation).

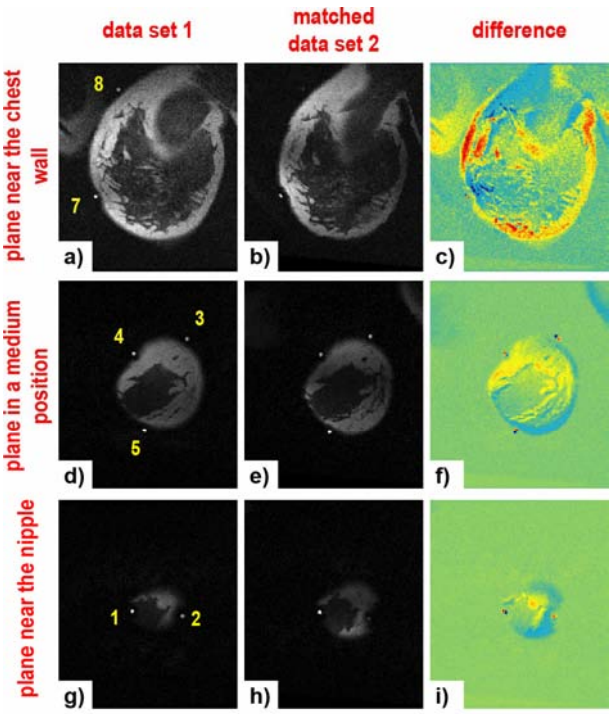

Figure 1: Images from the first 3D data set and the matched second 3D data set (first two columns) as well as the difference between the two sets (third column) at three selected (parallel) plane positions through the breast. The id-numbers next to the markers correspond to Table 1.

RESULTS

The positional variation of the markers between the 5 MR scans of each set was less than 1mm and thus below the expected displacement of the breast caused by respiration (in order of 2mm for shallow breathing according to [2].

One of the nine markers was not visible in the second set and therefore was not considered in the following analysis.

In figure 1 three specific slices containing markers from data set 1 and the matched data set 2 are shown. After the rigid body matching, variations in the positions of all markers over the entire breast are clearly visible in the difference between both sets. The measured differences are spatial uniformly and show no preferred direction. The measured distances in the marker positions between the first data set and the matched data set are summarized in Table 1 and are in the range from 1mm to 4mm.

DISCUSSION AND CONCLUSIONS

Based on the results of this first experiment, an image registration of pre-operative supine MR scans seems to be feasible, since the maximal observed positional variation was beneath 4mm. By evaluating the quality of the rigid body matching, the final registration technique used to register the pre-operative supine MR images with the situation in the OR will require additional elastic matching.

In the future, this experiment will be repeated with a number of volunteers to address expected variations of the results with age and breast size.

Table 1: Distances d in marker positions between data set 1 and the matched data set 2. The id-numbers of the markers increase with increasing distance of the marker to the nipple and are in accordance to the numbers given in fig. 1 (marker 6 is outside the shown planes).

id of marker	1	2	3	4	5	6	7	8
d [mm]	2.2	1.7	3.8	1.4	0.3	2.0	1.6	1.5

REFERENCES

[1] Huber ME, et al. Magn Reson Med 2001;45:645-652

[2] Sato Y, et al. IEEE Trans Med Imaging 1998;17:681-693