Registration of Breast MRI with Breast Ultrasound for Surgical Planning of Breast Conserving Surgery: A Feasibility Study

Martin D Pickles[1], Peter Gibbs[1], Anne Hubbard[2], Ayesha Rahman[2], Joanna Wieczorek[2], Ronjabati Roychaudhury[2], and Lindsay W Turnbull[1]

[1]Centre for Magnetic Resonance Investigations, HYMS at University of Hull, Hull, East Yorkshire, United Kingdom, [2]Breast Care Unit, Hull & East Yorkshire Hospitals NHS Trust, Hull, East Yorkshire, United Kingdom

Target audience: MR researchers, breast radiologists, breast clinicians, oncologists, breast radiographers/imaging technicians

Background: Given it's positive cosmetic outcome breast conserving surgery (BCS) is often favoured over breast mastectomy. However, positive tumour margin status following BCS remains a significant problem frequently necessitating reoperation until a negative tumour margin is achieved. Tumour margin positivity is the most important risk factor for recurrent disease post BCS. Positive tumour margin status can also result in poorer cosmetic effect, increased patient anxiety, delayed adjuvant therapy and increased treatment cost. In the UK approximately 20% of cases (NHS breast screening programme figures) require re-operation whilst much higher rates have been reported globally (~ 50%). Surgical management of early breast cancer relies either on the ability to palpate the tumour or to localise the mass by ultrasound or stereotactically guided wire insertion. The localisation of a lesion via a guide wire will be inaccurate if the full extent of the disease is not identified by the imaging modality used to guide the wire insertion. Given it's easy access and low cost ultrasound is frequently utilised to direct wire insertion yet the accuracy of ultrasound in delineating breast malignancies is known to be inferior than that of MRI.

Purpose: The purpose of this study is to evaluate the feasibility of utilizing registered breast MRI and ultrasound data in the surgical planning of BCS via guide wire insertion. The primary end point is the number of failed MR and ultrasound registrations. Secondary end point will be the rate of positive resection margins following BCS, as determined by histopathology of the excised specimen.

Methods: Initially participants underwent a MRI breast examination utilising a 3.0T MR750 (GE Healthcare) in combination with a 32 channel pelvic/torso phased array coil. In a similar fashion to Rizzatto et al.[1] prior to imaging four MR visible external fiducial markers were placed in the 12-, 3-, 6-, and 9-o'clock positions relative to the nipple. The locations of the external fiducials were marked with indelible ink. The participant was imaged in a supine position with the arm of the affected side abducted thereby emulating the ultrasound position. A plastic bridge was ultised to ensure that the anterior imaging coil did not deform the affected breast. Limited functional dynamic (4.5mins) and post contrast morphological (1.5mins) sequences were acquired with an average total scan time of ~6 mins.
Following the breast MRI examination participants underwent ultrasound and MRI registration immediately proceeding to guide wire localization utilizing a LOGIQ E9 ultrasound unit (GE Healthcare). The transducer of this US unit is fitted with integrated dual sensor magnetic positioning, consequently, the transducer position in 3D space with respect to a reference magnetic field is known. Initially, the MR dataset was loaded onto the US unit. The participant was again positioned in a supine arm abducted position. To aid co-registration common points identifiable in both the US and MR images must be identified. Therefore the transducer was positioned over the indelible ink marks (12-, 3-, 6-, and 9-o'clock positions relative to the nipple). This skin location is then identified on both the US and MR images. Three to four common points were located and then LOGIQ E9 reported the root mean square (RMS) value. The performing radiologist then scanned the whole breast and assessed the global registration in a qualitative fashion.

Results: Twenty-one participants have successfully undergone US/MR registration. To facilitate familiarisation of the registration process the first four cases were utilised as a training set. Consequently, the results of seventeen cases are presented. The median interval between MRI and US was 1 day (Min. 1, Max. 5). The median RMS was 4.0 (Min. 0.6, Max. 8.8). All US/MRI registrations were successful, including the training set. Global registration quality was qualitative scored as follows: very good 7, good 6, moderate 2, and poor 2. Histopathological margin status results are currently available for 16 cases (14 negative, 2 positive), resulting in a 12.5% positive tumour margin status rate. Typical co-registration of US and MR images are presented in Figure I.

Discussion: The results of this work demonstrate that the registration of US and MR data to aid in the insertion of surgical guide wires is feasible. Arguably, an alternative approach would be to insert guide wires solely under MR guidance. However, this not only necessitates dedicated localisation hardware and software but also much greater access to MR scanner time (typically a diagnostic scan followed at a later date by a wire guidance scan). The technique outlined in this work minimises the necessary MR scan time while maximising the diagnostic accuracy with the inclusion of MR data. Additionally, the wires can still be inserted in the customary manner, albeit with US/MRI co-registration, by the usual staff. In conclusion co-registration of US and MRI data to aid in the insertion of surgical guide wires is feasible

References:[1]Rizzatto et al. Eur. J. of Rad. 81 (2012) e332– e337
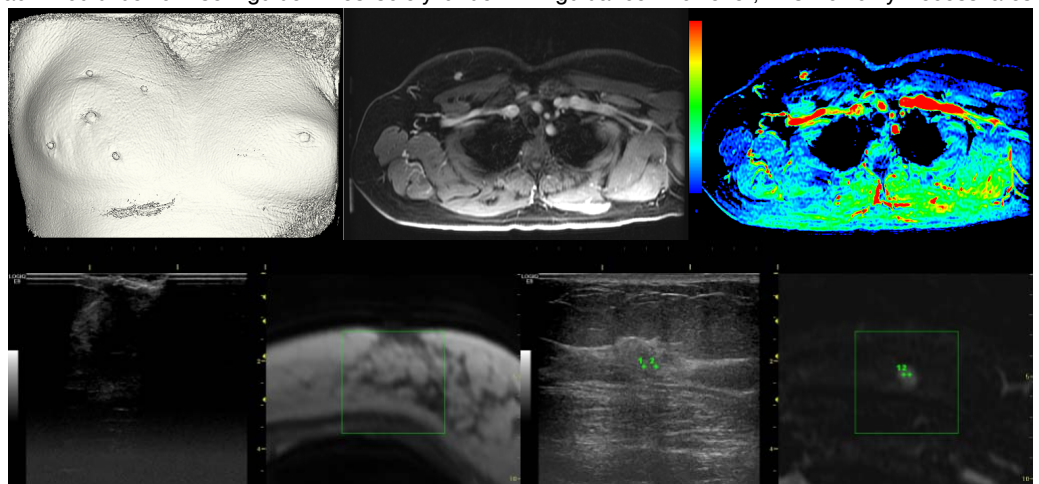

Figure I. *Top Row* Volume render demonstrating position of external fiducials, source image from dynamic sequence and positive enhancement integral map demonstrating an enhancing lesion superiorly within the RT breast. **Bottom Row** Co-registered US/MRI images demonstrating both good global (nipple) and lesion registration