Registration of Optical Navigator in Staged Musculoskeletal Procedures

Erkki Vahala[1], Riitta Parkkola[2], Risto Ojala[3], Teuvo Vaara[1], Mika Ylihautala[1], Gösta Ehnholm[1]
[1]Marconi Medical Systems Finland, Inc., Ayritie 4, Vantaa, Finland; [2]University of Turku, Department of Diagnostic Radiology, Turku, Finland;
[3]University Hospital of Oulu, Department of Radiology, Oulu, Finland;

Purpose
To investigate practicability of using a fast registration method for an optical navigator with musculoskeletal procedures performed in the close vicinity of an MR magnet.

Introduction
In some musculoskeletal procedures, the patient needs to be taken out of the magnet for a better access to the target area (a "staged" procedure). Such cases arise, for example, with obese patients, and in the case of bone biopsies where force needs to be applied to the instruments. Needle artefact based guidance is not possible outside the magnet, but other methods, e.g., optical tracking [1], can be used instead for improved accuracy in instrument aligning and targeting [2]. Moving the patient will, however, shift his coordinate system from that of the magnet. Tracking can still be done with the optical navigator, provided that it is re-registered to the images and the patient. Typically, this has been done with a point-and-click method, where three or more points are located on the images and retraced on the patient with the navigator. The method is time-consuming and error prone. We have investigated an alternative where two optical reference frames are used [3, 4]. In this method, the magnet has a fixed reference frame, provided by an integral tracker plate visible to the navigator. The navigator refers the orientation and position of any other tracker to the "magnet tracker". Assuming that the magnet tracker has been calibrated to the image coordinate system and the patient has not moved after the image acquisition, software is able to calculate position of the other trackers with respect to the image set. The patient movement is compensated with a second tracker plate which is attached directly to the patient: When the navigator has a line-of-sight to both the magnet and patient tracker, the calibration data can be automatically converted to a coordinate system where the patient tracker functions as the reference frame. Assuming that the patient tracker is rigidly attached to the anatomy from which the image set is taken, it is then possible to calculate the position of other trackers with respect to the fixed anatomy, irrespective of the relative position of the navigator and the patient. The patient can be moved out of the magnet and the instrument tracked, as long as the navigator has a line-of-sight both to the instrument and patient tracker.

Methods
A simple fixation device for attaching a patient tracker plate to the extremities was built (See Figure 1). It consisted of two L-shaped supports with straps. The blocks could be docked to a plate that fitted the patient couch of the 0.23 T open magnet (Proview, Marconi Medical Systems, Ohio). The tracker plate was attached to one of the blocks and commercial optical navigator system (*i*Path 200, Marconi Medical Systems, Ohio) used for navigating with the device. The system was demonstrated with a case where a large soft tissue tumour on the posterior side of the patient's left arm was biopsied under patient tracker guidance: The target area was supported with the blocks from both sides and strapped immobile. A FE3D-set was acquired from the target volume. The patient tracking was enabled through the user interface and the patient was moved out of the magnet, approx. 0.8 m, for a better access. The target point was selected and the needle guided to the target. Near real time 2D images were calculated from the 3D set using a multiplanar reconstruction (MPR) algorithm and updated on the display of the navigator system. The accuracy during the demonstration was ascertained by moving the patient back to the magnet. Verification images were obtained with fast FE2D sequences. The images contained the needle artefact, which could be used for estimating the accuracy of the guidance. Also the shape and position of the tumour could be inspected to confirm the level of immobilisation.

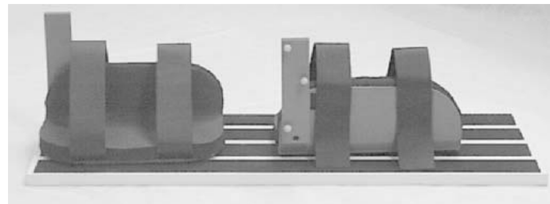

Figure 1. A fixation device for immobilisation. Also displaying the patient tracker plate with three reflective spheres.

Results
The coordinate conversion from the magnet to patient tracker was successful and navigator controlled MPR images provided data that allowed guiding the needle to the target. Verification images confirmed success in needle positioning. According to the images, tumour was immobile during the whole procedure and did not deform. Figure 2 shows the needle position in an MPR image just before the target was reached. It also shows the corresponding verification image, where the displayed overlaid graphics closely match the needle artefact.

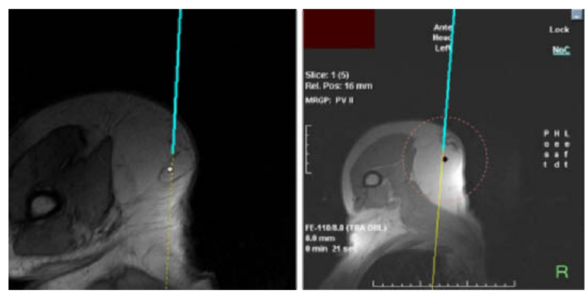

Figure 2. An MPR image (left) and subsequent verification image (right). Instrument is shown as a thick line, its extension line as a thin line. The target point is marked with a small sphere.

Discussion
Using two reference frames provided a fast method for calibrating the system in staged procedures. A simple fixation device was sufficient for providing the necessary rigidity for this soft tissue biopsy. The system could be further improved with more sophisticated fixation methods [5]. Performing the biopsy next to the magnet allowed frequent rescans and rapid re-registration, which decreased the risks associated with tissue movement and deformation.

References
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