Consistent automated scan planning of shoulder

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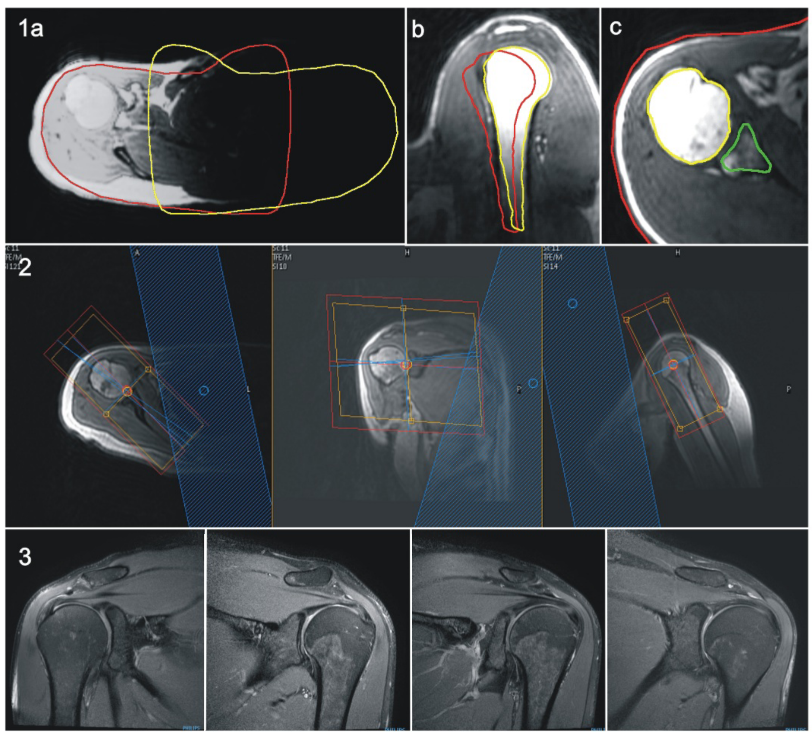
Introduction: Consistent planning of MRI scans between patients who undergo an shoulder examination is very important. It enables radiologists to investigate the patients' anatomy with a preferred 'orientation' and is of great importance for accurate operation planning, comparison and follow up. However, operators have different opinions on the best planning based on their training, competence and experience, which may hamper the consistency between MR images. To deal with this problem, an automated scan planning for shoulder examinations was developed. Segmentation of the skin surface, the humerus and the glenoid provides the anatomical references for planning slices, the shim volume and presaturation slabs. The planning can be trained to reflect the preferred planning of the radiologist.

Methods: Automated shoulder planning is initiated by the execution of a 3D TFE scout image of the region of interest, which takes 45 seconds. A number of landmarks describing parts of the anatomy are automatically detected by a model-based algorithm using 3D deformable mesh adaptation[1]. First, the scout image is non-linearly scaled to suppress high intensities from the humerus. Then, a predefined triangular mesh[1] describing the skin surface (skin-mesh) of the left shoulder and a similar mesh describing the skin surface of the right shoulder are projected on the centre of gravity of the scaled image, followed by mesh adaptation. After comparison of the similarity of the scaled image with both meshes the shoulder is identified. A predefined mesh describing the humerus is then positioned using the skin-mesh position and adapted using the pixel intensities of the original scout. Copies of a predefined mesh describing the glenoid are placed on several positions using the humerus as a guideline for the position. The copy with the best similarity to the original scout is selected, and this mesh is adapted to the shape of the glenoid. Finally, landmarks are derived from the adapted meshes to define the anatomy of the shoulder. To automatically plan the shoulder, the landmarks are compared with a database of landmarks. This database is setup by the user during a training phase and contains landmarks from typically 20 patients, including their manual planning of the scans, thus providing a global estimation of the preferred orientation of the anatomy in the stack with respect to the landmarks. Using correlation the best possible stack orientation for the new case is calculated[2]. The automated planning results were evaluated on volunteers by a skilled operator and in a real time clinical setting..



Results: In Fig. 1a, projections of the skin-mesh for left and right shoulder are shown. The skin-mesh for left shoulder (red) is selected to fit best to the anatomy, after which it is adapted using the mesh adaptation. The initial humerus-mesh (Fig. 1b, red) is adapted to fit the humerus (yellow). This is followed by placing the glenoid-mesh. The transversal view in Fig. 1c shows the final position of the three meshes. The position of the planning slices (red), the shim volume (yellow) and presaturation slabs (blue) is automatically estimated, as shown in example in Fig. 2 on a transversal, sagital and coronal view respectively. Off line planning on 40 patients after training the system was found to provide acceptable results. A real time scan in a clinical setting on 10 volunteers gave excellent results (see Fig. 3 for four cases).

Discussion/ conclusion: We demonstrated the feasibility of automated planning on shoulder. In brain automated planning is found to be very consistent [2]. The challenge with shoulder is to deal with the high variation caused by its flexibility and to deal with severe pathology, e.g. caused by fractures. To improve the planning, we will investigate the inclusion of other parts of the anatomy, e.g. acromion and we will investigate whether this type of planning is effective in use on patients in daily routine. Since the database with training cases can be shared between hospitals, the method will also be relevant for multi-site trials. In conclusion, we developed an automated scan planning procedure of the shoulder which is part of an examination protocol that defines and automates the entire examination, thus improving workflow and achieving a one push button examination. It enables the acquisition of the shoulder in a consistent manner which is preferred by the radiologist.

References: [1] J. Weese, et al. Proc. IPMI 2001, 380-387 [2] S. Young, et al. Proc. SPIE Medical Imaging 2006, 6144-58.