Characterization of a MRI Compatible Head / Neck Immobilization and Repositioning Device for Longitudinal Studies of the Carotid Artery

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Introduction

For longitudinal imaging studies of carotid lumen morphology and plaque growth it is important to be able to image vessel structures in the same configuration and orientation in order to identify the net change of disease.1 Accurate patient repositioning on the table provides better vessel registration and image comparisons with previous studies, thus improving patient care. The purpose of this work was to characterize a patient head and neck immobilization and repositioning device and assess its ability to immobilize and accurately reposition a patient on the MRI table. Characterization of this device was performed by evaluating vessel orientation changes as a function of head rotation angle using magnetic resonance angiography studies.

Methods

The head immobilization and repositioning device used in this study (see Figure 1) includes a base plate that is anchored to a consistent position on the patient table, a selection of foam head supports, and an arch that fits around the head and includes customized nose bridges for each patient and left-right stabilization posts. The individual elements of this device are all indexed and recorded for each patient for use in future studies. RF coils are also integrated with this device allowing 1) easy changing of coils, if necessary, 2) more consistent setup, compared to the towel and sponge approach, and 3) limited coil pressure on the neck for less deformation of the neck anatomy.

Characterization of this device consisted of volunteer imaging studies, where volunteers were positioned on the patient table Case 1) without the positioning device, Case 2) using the device, and Case 3) using the device and being repositioned on the table for several different scans. For each case, volunteers were asked to rotate their head in several different angles of left/right and flexion/extension rotation. For each imaging study, fiducial markers were used to compute the head translation and rotation angles, and for each data set, vessel orientation angle changes were measured and compared with reference data sets (no head rotation). The vessel orientation changes were plotted vs. relative head rotation. Vessel orientation changes were categorized based on vessel segment and head rotation direction. Finally, this device was used for a longitudinal studies of patients with carotid disease.

Results

Results for all three cases are given in Figures 2 and 3. These plots present a complete summary of the net vessel orientation change as a function of head rotation. As expected, these figures show that when the head is restrained and not allowed to rotate, the vessel orientation angle changes are minimal, less than 3° for left/right rotation and less than 4° for flexion/extension, when the volunteers are trying to rotate their head. In general, vessel orientation angles can be seen to increase with increasing head rotation angles. Using the complete head positioning system to reposition the volunteers limited the vessel orientation angle changes to less than 5°. Longitudinal studies of diseased patients using the device show that there is improved vessel and disease registration and general vessel depiction when compared to studies performed without the device (Fig. 4)

Conclusions

These experiments provided an overall understanding of the effects of head rotation on vessel displacement and relative orientation angle. This study demonstrates that variations in both head position and vessel orientation are significantly reduced when using the head/neck positioning device. The consistent patient setup provided by this device reduces variations in vessel morphology appearance and results in more consistent and reliable longitudinal studies of the carotid arteries. This allows for more meaningful studies of plaque growth and disease development.

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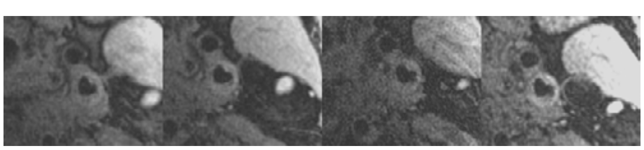

Figure 4. Images from longitudinal study over 7 weeks.

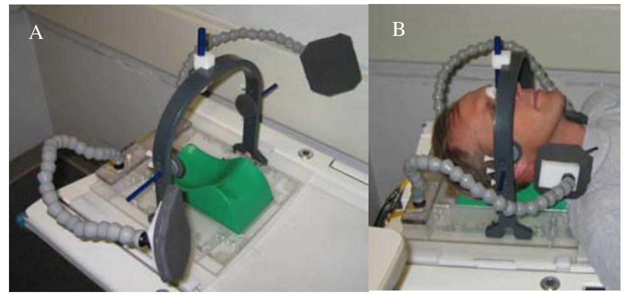

Figure 1. A) The head / neck positioning and immobilization device and carotid coils. B) A standard patient positioning setup.

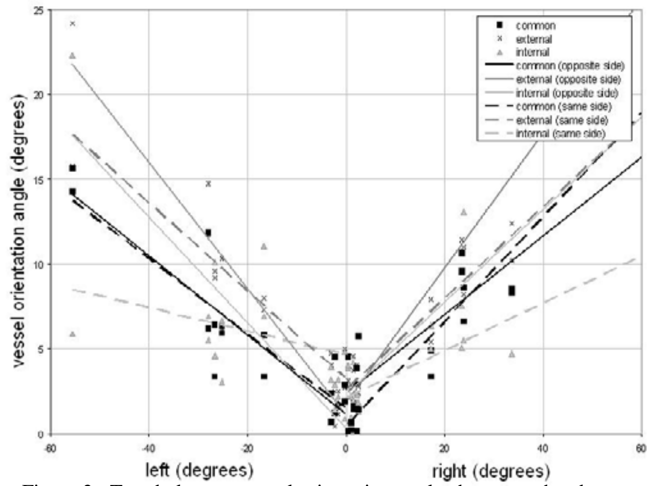

Figure 2. Trend plot: net vessel orientation angle change vs. head rotation in a left/right rotation angle.

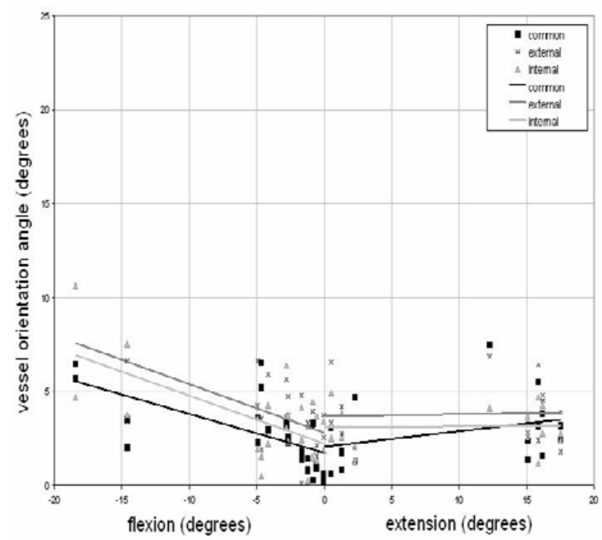

Figure 3. Trend plot: net vessel orientation angle change vs. head flexion (chin down)/ extension (chin up) angle.