Development of a Stereotactic Radiosurgery Frame Adapter for a Multichannel MRI Coil

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Introduction

- 3.0 T MRI scanners have been used to acquire MR images during SRS procedures instead of the 1.5 T MRI scanners because of various advantages
- Accuracy is required with respect to the MR image geometry for planning treatment during an SRS because SRS requires high geometric accuracy to allow precise delivery of high radiation dosage to small target regions
- The geometric error between the computed tomography (CT) images and MR images obtained without using frames is larger than that associated with the conventional frame-based SRS because of more frequent head motion in the frameless SRS technology
- Because the SRS frame is designed to fit with a single-channel brain coil, a frame adapter device is required to fit the frame inside the multichannel brain coil to use the multichannel brain coil with SRS frame when using 3.0 T MRI scanner

Methods

- Frame Adapter Development:
  Designed using the CATIA program and printed using a 3D printer. Made of polylactic acid and fits inside a 48-channel brain coil.

- Phantom CT and MR Image Acquisition:
  MR images of the phantom were acquired using both multichannel and single-channel coils.
  CT images of the phantom were obtained with specific imaging parameters.

- Geometric Accuracy Evaluation:
  CT and MR images of the phantom were analyzed in a gamma plan workstation.
  Two neurosurgeons measured the 3D coordinates of 112 marker points.
  Differences in the measured coordinates were calculated.
  Geometric accuracy of the MR images for both coil types was estimated by comparing them to the CT images.

- SNR Measurement
  Background noise of the MR images was estimated from four regions of interest.
  SNR maps of the images were produced and normalized.
  Brain images were obtained from a single participant, who provided consent.

- Statistical Analysis:
  Pearson’s correlation analysis measured interpersonal errors.
  Differences in coordinates from T1- and T2-weighted images between the two coil types were compared using an independent two-sample t-test.
  Various statistical tests were used, depending on the data's characteristics.
  A significance level was set for different statistical analyses.

Results

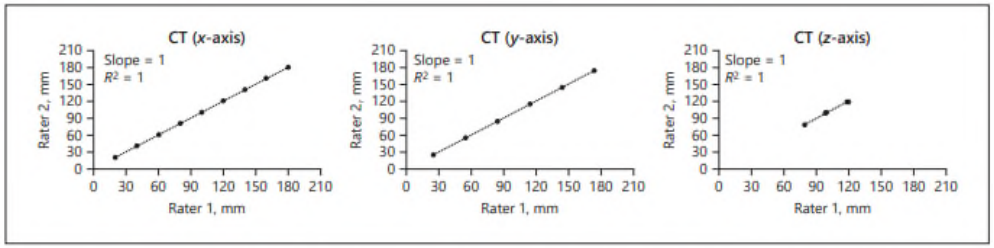

Fig. 3. Results of fitting the linear model to correlate the coordinate values obtained using the 2 raters based on CT images. CT, computed tomography.

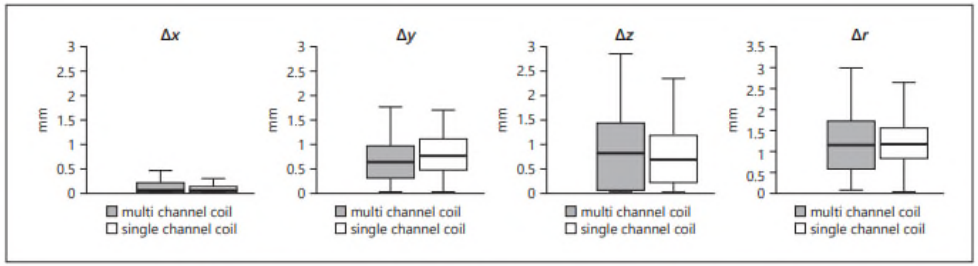

Fig. 5. Coordinate errors (Δx, Δy, Δz, and Δr) of the T2-weighted MR phantom images for single- and multichannel coils.

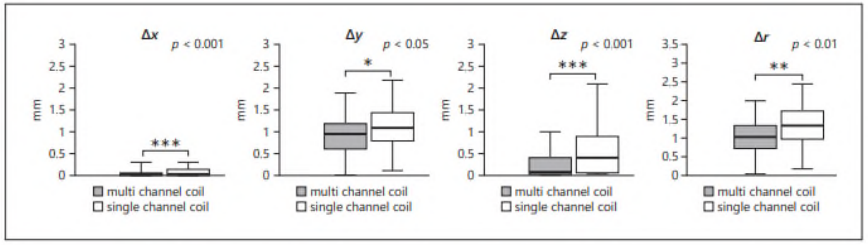

Fig. 4. Coordinate errors (Δx, Δy, Δz, and Δr) of the T1-weighted MR phantom images for single- and multichannel coils.

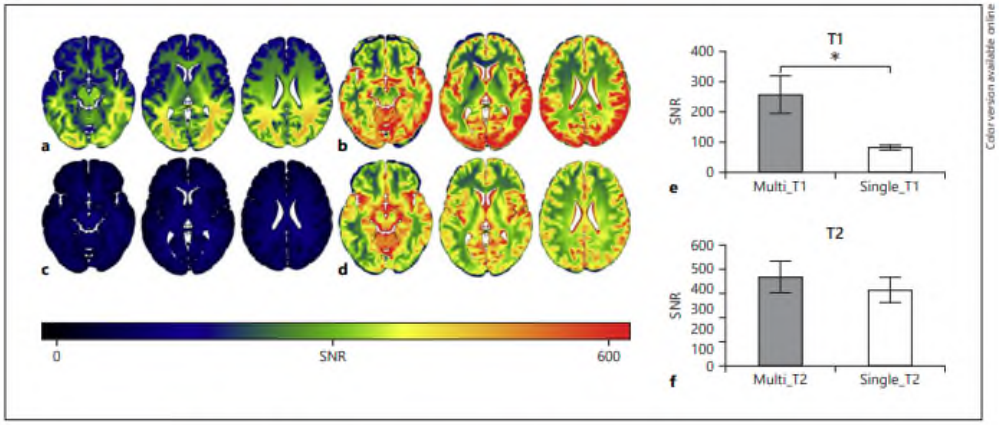

Fig. 6. SNR maps. **a**, **c** SNR maps obtained from the T1-weighted images using multi- and single-channel coils, respectively. **b**, **d** SNR maps obtained from the T2-weighted images using multi- and single-channel coils, respectively. **e**, **f** Mean SNRs of the whole brain for the T1- and T2-weighted images, respectively. A relatively nonspecific arbitrary unit is considered to be the scale. SNR, signal-to-noise ratio.

Conclusion

- Compared with a single-channel coil, the MR phantom images obtained using a multichannel coil when using the developed frame adapter showed higher geometrical accuracy
- The brain MR images obtained using a multichannel coil showed higher SNR than that obtained using a single-channel coil
- The use of multichannel MRI coils with the newly developed frame adapter is expected to be useful for successful SRS treatments in the future