

Inter-rater and Intra-rater Reliability of cineFSE Carotid Measurements

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Target audience: This research will be of interest to those imaging the carotid arteries and others using cardiac-gated imaging sequences. Additionally, the work may benefit those interested in arterial distensibility in the context of stroke prevention.

Purpose: Decreased carotid distension has been implicated in the development of atherosclerosis and is associated with increased stroke risk [1]. MR imaging of the carotid arteries and their elasticity is a topic of recent interest [2,3]. Evaluation of carotid distensibility hinges on accurate and precise measurement of cross-sectional areas of the carotid artery during systole and diastole. Repeatability is necessary for effective assessment of disease progression/regression; inter- and intra-rater reliability must result in a minimum detectable difference (MDD) less than the physiological changes with disease. We recently applied a retrospectively gated cine fast spin echo (cineFSE) sequence [4] for imaging carotid distension over the course of the cardiac cycle. In the current work, we investigate the repeatability of manual carotid segmentation when using cineFSE images and to compare the results to repeated measurements obtained using prospectively gated fast spin echo (pFSE) and cine gradient recalled echo (cineGRE) techniques.

Methods: One axial slice of the common carotid arteries was analyzed across ten healthy young volunteers. Images acquired were: one 16 cardiac phase cineGRE sequence (TR/TE/α = 17 ms/6.1 ms/30°, FOV 160 x 160 mm, 256 x 256 matrix), 4 cardiac phases of pFSE images (TR/TE/α = 2*RR/13 ms/90°, FOV 160 x 160 mm, 256 x 256 matrix), and three acquisitions of a 16-phase cineFSE sequence (TR/TE/α = 1.2*RR/13 ms/90°, FOV 160 x 160 mm, 256 x 252 matrix). Images were randomized by subject and sequence but left in cardiac phase order when presented to three reviewers. All reviewers manually traced the left common carotid artery in each image three times (non-sequentially) using Osirix software [5]. The repeated measurements were used to concurrently analyze both inter- and intra-rater reliability via intra-class correlation coefficients (ICC) [6]. Additionally, single measurements on three repeated cineFSE acquisitions were used to determine the scan-rescan reliability of the technique.

Results: Mean cross-sectional common carotid area was $28.0 \pm 0.2 \text{ mm}^2$ on cineFSE images, $27.9 \pm 0.3 \text{ mm}^2$ on pFSE images, and $35.8 \pm 0.4 \text{ mm}^2$ on cineGRE images. The cineGRE images had significantly higher cross-sectional areas ($p < 0.01$) than the FSE images. Inter- and intra-rater reliabilities and MDD for each technique are shown in Table 1. Scan-rescan ICC for cineFSE was 0.92 based on the average of all rater tracings over the three repeat acquisitions.

Discussion: Manually traced carotid cross-sectional areas (Figure 1) were highly repeatable on both FSE and cineGRE techniques. An MDD of 5.8 mm^2 with an average cross-sectional area of 28 mm^2 , implies a reliably detectable change in area of 21%. Given that a healthy common carotid artery pulses with an area change of ~32% [7], all three sequences tested here are capable of detecting typical carotid distension. Cross-sectional carotid areas had low variability between successive cineFSE acquisitions. However, a smaller MDD will likely be necessary to fully characterize decreased distensibility with disease state. To achieve this, an increase in precision may be possible with a higher resolution afforded by the use of dedicated carotid coils.

Conclusions: Retrospectively gated FSE (cineFSE), prospectively gated FSE (pFSE) and cineGRE techniques provided comparable inter-/intra-operator variability in manual measurements of carotid cross-sectional area. cineFSE measurements produced the smallest detectable difference in changes of cross-sectional area, sufficient for characterizing pulsation over the cardiac cycle in a healthy population, making this a viable technique for clinical evaluation.

References

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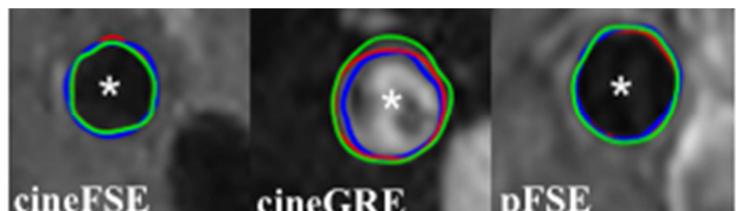


Figure 1 – Examples of three different rater tracings (red, green, blue) overlaid on cineFSE, cineGRE and pFSE images. Asterisk indicates carotid artery lumen for reference.

	cineFSE	pFSE	cineGRE
Inter-Rater ICC	0.88	0.85	0.88
Intra-Rater ICC	Rater 1	0.94	0.95
	Rater 2	0.86	0.79
	Rater 3	0.89	0.86
MDD Carotid Area (mm²)	5.8	7.4	7.8

Table 2 – Inter-/Intra-Rater intra-class correlation coefficient (ICC) and minimum detectable difference (MDD) results based on repeated cross-sectional area measurements of the common carotid artery using cineFSE, pFSE and cineGRE images.