Comparison of different techniques for non-contrast –enhanced and contrast-enhanced Magnetic Resonance Angiography of the Carotid arteries

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Purpose: Since the introduction of magnetic resonance imaging (MRI) in clinical routine vascular imaging always has been a challenge. Early MR angiography (MRA) techniques were based on intrinsic contrast mechanisms related to blood (non CE techniques). The development of contrast enhanced (CE) MRA techniques using gadolinium based contrast agents (GBCA) substantially changed vascular MR applications and pushed the envelope for non-invasive vascular diagnosis. However, the advent of nephrogenic systemic fibrosis (NSF) with a possible direct link to the application of GBCA triggered a renaissance of non CE MRA with the development of new techniques. Purpose of the study was to compare 5 different techniques for magnetic resonance angiography (MRA) of the carotid arteries among which three are non CE [1] and two are CE MRA techniques [2] in an intraindividual setting. To the best of our knowledge there is no study published comparing established and newly developed non CE and CE MRA techniques in an intraindividual comparison.

Materials and Methods: 35 consecutive patients (mean age 63±16, 14m/21f) referred for MRA of the carotid arteries were enrolled in this IRB approved study. The study protocol consisted of: Time of Flight MRA, T2w darkblood MRA, ECG gated TrueFISP MRA, CE dynamic MRA and standard high-res CE MRA in a single session on a clinical 3.0T MR system (**figure 1, table 1**). Prior to patient enrollment each technique was optimized. For comparability reasons spatial resolution of all technique was harmonized to 0.9 x 0.9 x 0.9mm^3. exept dynamic MRA featuring a spatial resolution of 1.1 x 1.1 x 1.1mm^3 to achieve a reasonable high temporal resolution of 3.5sec/frame. CE MRA techniques were performed with a standardized overall dose of 20ml 0.5 molar contrast agent consisting of 1.5ml test bolus, 4.5ml for dynamic CE MRA and 14ml for the high resolution static CE MRA. Datasets were evaluated in terms of image quality (IQ) by means of delineation of the vessel lumen, homogeneity of signal within the vessel and the diagnostic confidence for each single technique by two readers on a four point scale whereas 4 stands for the best, 1 for the worst score. Furthermore readers had to rank the technique in every single individual from their most preferred to the most inappropriate technique. For quantitative evaluation of the different techniques two different readers measured the cross sectional luminal area at three pre-defined levels for all techniques in every patient using CE MRA as the standard of reference. Results were evaluated in terms of significant differences between the techniques and for inter reader agreement.

Results: In three patients the exam was finished prematurely because of claustrophobia; and one patient has been excluded because of aplasia of the carotid arteries. Hence, data of 31 patients was available for evaluation. The IQ assessment rated high-res CE MRA best (mean score: 3.61) followed by ECG gated TrueFISP (mean score: 3.09). Diagnostic confidence was again rated best for high-res CE MRA (mean score: 3.77), again followed by ECG gated TrueFISP (mean score: 3.11). The ranking in regard to the most preferred techniques was as follows: high-res CE MRA, ECG gated TrueFISP MRA, dynamic CE MRA, T2 w darkblood MRA and TOF MRA (**table 2**). However, no significant differences between reader scores for the qualitative parameters could be found. Quantitative cross sectional luminal area measurements showed no significant differences within the same technique between both readers but in some cases significant differences between different techniques occurred. When comparing all other techniques to CE MRA as a standard of reference, only ECG gated TrueFISP MRA showed no siginificant differences (table 3).

Conclusion: CE MRA today still serves as the standard of reference in MRA techniques because it serves excellent image quality and high accuracy. But when it comes to non CE MRA techniques there are some alternatives of which ECG gated TrueFISP MRA turns out to be the most accurate and comparable technique.

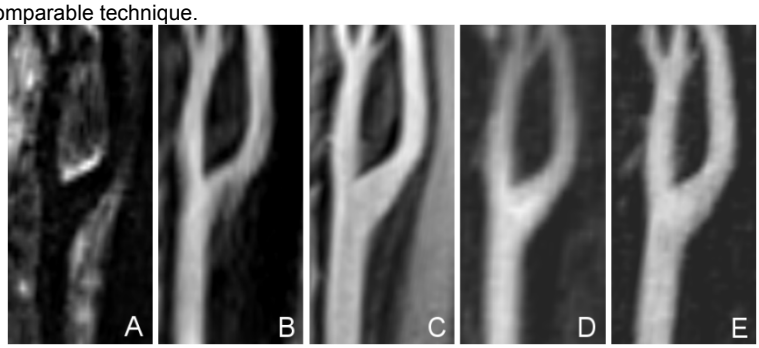

Figure 1: Examples of all 5 techniques for imaging of the carotid bifurcation: T1 weighted darkblood MRA (A), time of flight (TOF) MRA (B), ECG gated TrueFISP non CE MRA (C), dynamic CE MRA (D) and static CE MRA (E)

Sequence	DB	TOF	TrueFISP	dyn. MRA	CE MRA
acq.time	5:19	3:04	~5:00*	1:08	0:18
TR	1900	18	1622.18	3.09	3.06
TE	171	2.66	1.81	1.14	1.17
spat. Res.	0.9x0.9x0.9	0.9x0.9x0.9	0.9x0.9x0.9	1.1x1.1x1.1	0.9x0.9x0.9
temp. Res.	*na*	*na*	*na*	3.52	*na*
Matrix	256	256	320	256	320
FOV	220	220	280	280	280
Slices	52	52	88	60	88
PI / ref. lines	2 / 24	2 / 24	2 / 24	3 / 24	3 / 24
BW	454	250	781	650	650
flip angle	25	25	70	25	20
orientation	coronal	transversal	coronal	coronal	coronal

Table 1: sequence parameters of all 5 MRA techniques. *TrueFISP MRA is ECG gated and therefore acquisition time is heart rate dependent.

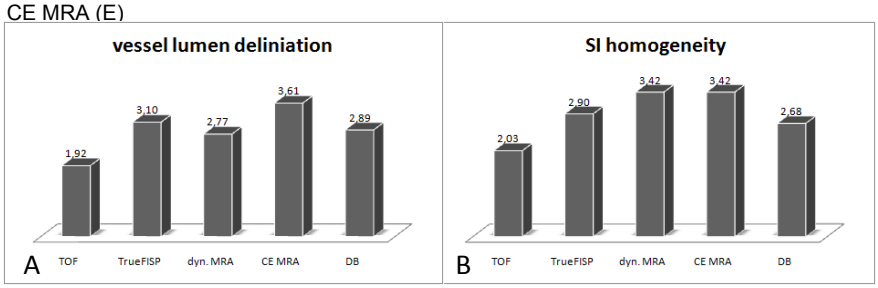

Table 2: Evaluation of vessel lumen delineation (A) and SI homogeneity within the vessel (B) for all used MRA techniques.

		CE MRA	
	level 1 45.96±11.75	**level 2** 63.71±21.98	**level 3** 31.27±15.31
T2w DB	*p<0.05* 40.31±12.01	*p<0.05* 49.29±17.57	*p<0.05* 27.21±12.67
TOF	*n.s.* 45.06±13.99	*p<0.05* 56.54±21.73	*n.s.* 30.98±16.15
TrueFISP	*n.s.* 47.63±14.46	*n.s.* 65.33±24.9	*n.s.* 32.98±12.99
dyn. MRA	*p<0.05* 55.62±13.79	*p<0.05* 72.92±22.4	*p<0.05* 37.67±13.74

Table 3: Comparison of cross sectional luminal area of CE MRA to all other techniques at three predefined levels. Only TrueFISP MRA shows no significant different results at all levels.

[1]Miyazaki M, Lee VS. Nonenhanced MR angiography. Radiology 2008; 248:20-43
[2] Yang CW, CARR JC, et al. Contrast enhanced MR angiography of the carotid and vertebrobasilar circulations. AJNR 2005; 26:2095-2101