Vessel Visualization Enhancement in Parallel Imaging 3D-TOF MRA Utilizing Surface Array Sensitivity

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SYNOPSIS

Array coils have an important role for improving SNR and realizing parallel imaging, however, one of disadvantages of array coils is non-uniformity of sensitivity. We propose a simple algorithm to enhance blood vessel visualization in 3D-TOF-MRA utilizing this surface array sensitivity, and applied it to normal volunteers' MRA data. We have verified that peripheral vessel visualization capability is remarkably improved.

INTRODUCTION

Array coils have an important role for improving SNR and realizing parallel imaging (PI) [1, 2]. However, one of disadvantages of array coils is non-uniformity of sensitivity. Appropriate correction of coil sensitivity is quite important for expressing the original contrast. This sensitivity correction consists of two steps: 1) estimation of coil sensitivity distribution *S (x,y,z)*, and 2) correcting procedure itself which is basically multiplication of *1/S(x,y,z)* to the target image *F(x,y,z)*. For MRA applications, this non-uniformity correction is very significant, because the following maximum intensity projection does not work well unless the background signal intensity is uniform [3]. On the other hand, surrounding surface array coils pick up high intensity signal from the peripheral vessels in the head. However, the conventional sensitivity correction compresses this emphasized signal. A technique to extract maximum information of vessels from the array coils is desired. In this paper, a simple algorithm to enhance blood vessels in 3D-TOF-MRA utilizing surface array coil sensitivity is proposed, and its performance is verified.

ALGORITHM

Now, the signal intensities of brain parenchyma should be uniformly corrected, and highly enhanced signal intensities of peripheral vessels should be maintained. To realize these two, our algorithm was formulated as follows; *S(x,y,z)* is a sensitivity map and *F(x,y,z)* is a target image data. As the concept of sensitivity correction is generalized, correction procedure is just called "signal intensity (SI) correction", hereafter.

F', S': mean values of *F (x,y,z)* and *S (x,y,z)* of some brain parenchyma area in the center of the imaging volume,

Fn (x,y,z) = F (x,y,z) /F', Sn (x,y,z) = S (x,y,z) /S': normalize image and sensitivity map,

Then, our SI correction is defined as follows by using a conversion function *C* (Fig.1 (a)),

Fc (x,y,z) = C (Fn (x,y,z), Sn (x,y,z)),

where the function *C* is defined satisfying the following conditions; 1) *C* is a function depending not only on *Fn* but also on *Cn*: 2) if *Fn = Sn*, then *C (Fn, Cn)* = 1, 3) if *Fn>=Cn*, then the differentiation *dFn/dCn* = 1. It means that the SI of brain parenchyma in *Fn* is always one and the SI difference between the enhanced vessels and the parenchyma is maintained. *Fc * F'* is a final corrected value. This IC method is called Intensity Correction utilizing surface Array Sensitivity (ICAS).

Conventional SI correction to multiply *1/ S(x,y,z)* as mentioned above is simply expressed as *Fc (x,y,z) = Fn (x,y,z) / Sn (x,y,z) *F'* (Fig.1 (b)).

METHODS

3D-TOF MRA data of the head of normal volunteers were obtained on a 1.5-T clinical imager, equipped with a 10-element 7-ch QD Head coil based on a 4-channel QD Coil for fMRI [4]. Sensitivity map was obtained by a pre-scan. Typical MRA sequence was used in conjunction with parallel imaging with reduction factor *R* of 2. Two sets of MRA source images were obtained from the same raw data by using (a) ICAS processing and (b) conventional SI correction. After that, ICAS and conventional MR angiograms were evaluated for vessel visualization capability.

RESULTS

Both of (a) ICAS and (b) conventional source images had sufficiently uniform SI of brain parenchyma with no apparent artifact. MIP images are shown in Fig.2. Peripheral vessels in ICAS MRA had higher signal intensity compared with conventional one, as expected. To clarify the difference, subtracted images (a)-(b) are shown in Fig.2 (c), and signal intensity profiles are also shown in Fig.2 (d) and (e) corresponding to the lines in (a) and (b), respectively.

DISCUSSION

In the intracranial MRA study, not only main cerebral arteries but also peripheral vessels should be visualized. ICAS is the technique for the latter like previously reported several techniques such as TONE or SORS [5, 6]. Therefore the TONE pulse effect could be weakened with ICAS, and main arteries may be visualized better. By the way, the effect of ICAS is adjustable by changing the function C. This flexibility can be helpful for clinical usage.

In conclusion, peripheral vessels in ICAS MRA had higher signal intensity compared with conventional MRA. ICAS approach could be more important, because the non-uniformity of sensitivity can be larger as the number of array coil channels, tending to increase in near future.

REFERENCES

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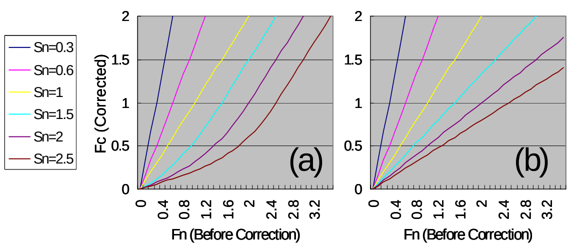

Fig.1 Intensity Conversion Function
(a) ICAS, (b) Conventional Sensitivity Correction

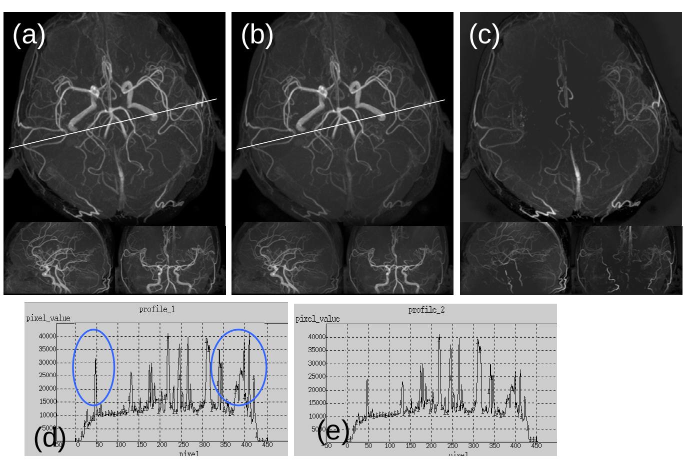

Fig.2 MR Angiograms:
(a) ICAS, (b) Conventional Sensitivity Correction,
(c) Difference (a)-(b), (d, e) profile data corresponding to (a) and (b)