Fold-Over Aliasing Artifact Suppression Technique in MR Parallel Imaging: Considerations of Role of FOV in Image Formation Procedure

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INTRODUCTION

Among various MR parallel imaging (PI) techniques such as SMASH and SENSE [1-4], image domain techniques are most widely used [2, 4]. However, a fold-over/ aliasing artifact (FAA) is often observed in the center of images [5]. This artifact appears, when the final reconstructed full field-of-view (FOV) image is smaller than the object being imaged. Although the FAA can be removed by employing a sufficiently large imaging FOV [5], it induces lower imaging performance and troublesome operations. In order to overcome this problem, we have reconsidered the role of FOV in many stages of image formation procedure in image domain MR parallel imaging technique. Furthermore, an FAA suppression algorithm named Extended PI Algorithm for Unfolding (EXPAND) which employs a larger FOV for unfolding procedure is introduced, and its performance is verified.

THEORY

Let *R* be a reduction factor in Parallel MRI. Several kinds of FOV in the phase encoding (PE) direction are defined here;

a) *FOV_plan*: FOV set by an examiner in scan planning procedure
b) *FOV_acquis*: data acquisition FOV defined by "*FOV_plan / R* "
c) *FOV_unfold*: FOV on which unfolding procedure is carried out
d) *FOV_final*: FOV of final registered image

Among these, *FOV_final*: should be the same as *FOV_plan (= FOV_acquis * R)*, because these are what the operator wants to obtain. In other words, they are external parameters. On the other hand, *FOV_unfold* is an internal one, and therefore, this parameter can be set independently (up to the number of coil elements). However, "*FOV_unfold = FOV_final (= FOV_plan)*" is ordinarily employed in conventional unfolding procedure [2, 4].

We have emphasized and utilized this nature from the practical application point of view. .Proposed technique, EXPAND, is defined as a modified unfolding algorithm with "*FOV_unfold > FOV_final (= FOV_plan)*" followed by the extraction procedure of a *FOV_final* image from an intermediate *FOV_unfold* image (Fig.2). In this unfolding procedure, prior information of the object being imaged is utilized [4].

METHODS

All experiments were conducted using a 1.5-T clinical imager, equipped with a 16-element 8-ch QD Torso PI coil [6] or 10-element 7-ch QD Head PI coil [7]. Parallel imaging data of normal volunteers of the heart, the body, and the head with a reduction factor R of 2 were acquired. Imaging FOV was purposely placed such that it was slightly unfitted to the volunteer's shape. Both of conventional PI images and EXPAND images were reconstructed from same raw data. *FOV_unfold* was set to *FOV_acquis* *3 in the EXPAND reconstruction, instead of *FOV_acquis* *2. Obtained images were then evaluated for FAA.

RESULTS

Typical examples are shown in Figures 2 to 5;

(1) Cardiac Cine Images: As shown in Fig.2, an apparent FAA was observed in the conventionally reconstructed image. On the other hand, the EXPAND image had no artifact, as expected. Another case with a smaller FOV_plan is shown in Fig.3. No FAA but slightly degraded SNR was observed in the central part of the EXPAND image (arrows).

(2) Coronal Torso Images: The FAA appeared in the central part of conventional image, while no FAA was seen in the EXPAND image. (Fig.4)

(3) MRA of the Head: In this case, FAA of the ears was in the conventional image. No FAA was observed in the EXPAND image. (Fig.5)

DISCUSSION and CONCLUSION

Figure 2 shows the most effective EXPAND case, because the unfolding process is carried out with a factor of up to 2 for whole imaging points in the *FOV_unfold* (=*FOV_acquis* *3) region. This case is just same as Fig.1 case. As mentioned above, the EXPAND image in Fig.3 has slightly degraded SNR, because of higher *g* value due to 3-fold unfolding in this region. This degradation depends on scan positioning and coil geometry, and is one of penalties of EXPAND; however, it is less obstructive than FAA in the conventional image in most clinical cases. Regardless of its simple formulation, EXPAND works well in various cases even with higher *R* case.

As the number of channels or coil elements tends to increase, MR parallel imaging performance varies more continuously with respect to several imaging conditions. In such condition, EXPAND will work more efficiently.

We have reconsidered the role of FOV in parallel MRI, and introduced the EXPAND technique. We believe that EXPAND is useful for clinical cases using parallel imaging, because of no FAA, which is clinically troublesome.

REFERENCES

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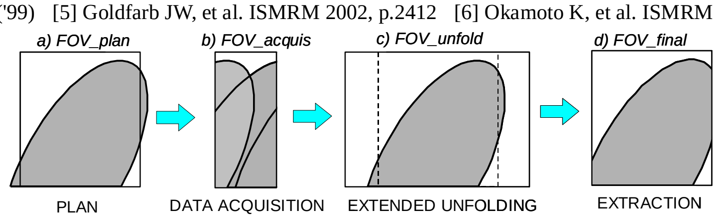

Fig.1 EXPAND algorithm

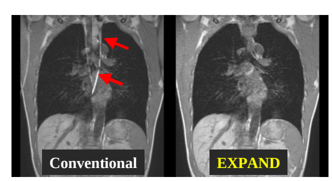

Fig.4 Coronal Torso Images

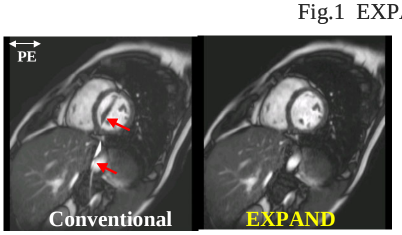

Fig.2 Cardiac Cine Images

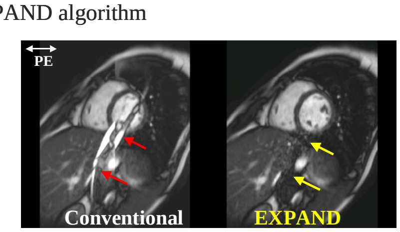

Fig.3 Cine Images with Smaller *FOV_plan*

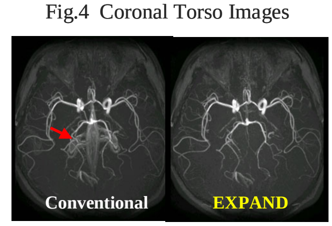

Fig.5 MRA of the Head