# Reducing Needle Induced Image Artifacts in Interventional MRI while Maintaining Soft Tissue Contrast

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**Target Audience:** Clinicians and physicists interested in reducing needle induced artifacts in intervention MRI.

**Introduction:** Image guidance plays an important role in minimally invasive procedures, such as biopsies or ablations to tissue. MRI has great potential to improve the ability to 1) track the needle position, 2) distinguish diseased from healthy tissue and 3) monitor treatment effect [1]. However, the needles typically cause severe imaging artifacts, and reduce the precision of the needle localization. Balanced-SSFP (bSSFP) offers good T2/T1 tissue contrast and is a fast imaging technique that minimizes patient motion, but banding artifacts are present due to its signal dependence on resonant frequency [2,3], hindering needle tip localization. Gradient Spoiled (GRE) and RF-Spoiled Gradient-Echo (SPGR) sequences eliminate the banding artifacts, but result in decreased T2/T1 contrast [3]. This study presents a special case of a GRE sequence, integrated-SSFP (iSSFP), that reduces needle induced banding artifacts from bSSFP, while maintaining similar T2/T1 contrast [4].

**Methods:** Phase cycling is a technique that reduces resonant frequency dependency for bSSFP by combining each (usually 2 to 4 phase cycles) cycled image using a complex sum, sum of squares, or other combinations [4]. We used two phase-cycled images combined using a complex sum ($\Delta\theta = 90°$ and $\Delta\theta = 270°$ phase cycles) to minimize imaging time and kept the same repetition time for both bSSFP and iSSFP.

The iSSFP sequence was implemented on a 3T scanner (TRIO, Siemens Healthcare, Erlangen, Germany) and compared to bSSFP, GRE, and SPGR sequences (Fig. 1). An ex-vivo meat slab was imaged with a 20 Gauge Inconel (nickel-chromium super alloy, about 0.9mm thick) MRI-compatible needle (Cook Medical MReye Disposable Chiba Biopsy Needle), inserted 5cm at 8 different angles to the $B_0$ field. The needle insertion angles were arbitrarily chosen to obtain a variety of needle induced artifacts, since the artifact is dependent on the needle orientation to $B_0$ field [5]. The images were used to assess the average needle tip error between scanned images and actual insertion length, and the width of the needle artifact for bSSFP, iSSFP, GRE, and SPGR sequences (Fig. 1). Common imaging parameters for all sequences were FOV 1.1 x 1.1 x 4 $mm^3$, 6 slices, 50° flip angle, and total scan times < 20s. OsiriX was used to measure the length of the scanned image needle tip location and the width of the artifact.

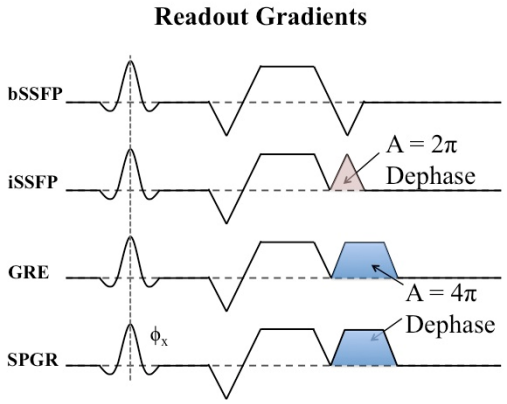


***Fig 1****: Illustration of RF-pulse and readout gradients for all four fast imaging sequences (bSSFP, iSSFP, GRE, and SPGR). The gradient area of the dephasing gradient in iSSFP was determined such that it would disperse the spins in each voxel across 2π.*

**Results:** The needle-induced artifacts are more severe in bSSFP images compared to the other sequences (see fig. 2 bottom row arrows). The needle tip error and the width of the needle artifact were least using the iSSFP sequence with needle artifact being 9.44mm wide and the needle length being 1.44mm longer, on average, in the image compared to actual insertion length (5cm). The bSSFP images had the largest needle tip errors, 2.48mm, and artifact width, 9.77mm (see table 1). The arrows in top row of fig. 2 point to features in the meat that are seen in bSSFP and iSSFP, but not in GRE and SPGR.

**Discussion and Conclusions:** The modified GRE sequence, iSSFP, had the smallest needle tip error and artifact width compared to the other sequences. The contrast of the features seen in the bSSFP images (fig. 2 top row arrows) is not as poignant in iSSFP images, but those features are not present in GRE and SPGR sequences. The decrease in the contrast of iSSFP is due to the averaging of the bSSFP signal from the 2π dephasing gradient. Future studies will evaluate the extent of the signal decrease. This study demonstrates that iSSFP reduces the needle tip error and needle artifact width compared to bSSFP, and qualitatively shows that iSSFP has similar contrast to bSSFP. These characteristics can be useful in the development and study of interventional MRI procedures, especially those that need a faster imaging acquisition, soft tissue contrast comparable to bSSFP, and improvement of needle localization.

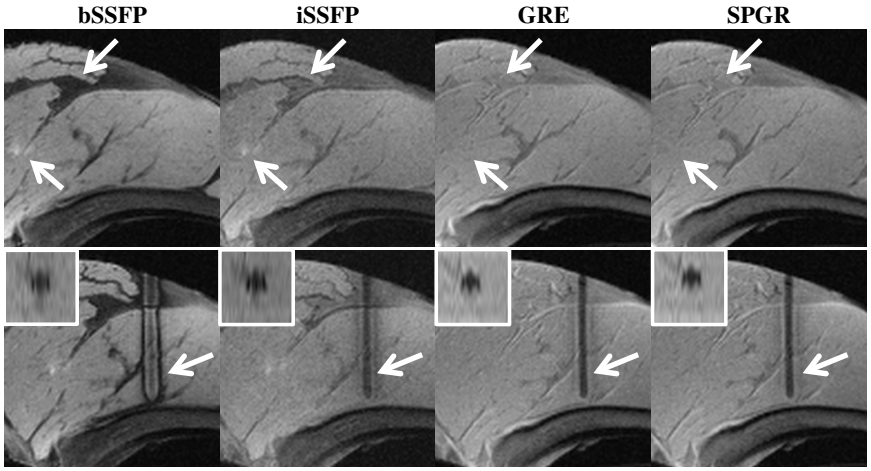


***Fig 2:*** *Comparison of bSSFP, iSSFP, GRE, and SPGR without needle (top row) and with needle (bottom row) inserted. Bottom row images have coronal displays of needle artifacts in top left corner. Top row arrows point to features that are seen in bSSFP and iSSFP, but not GRE or SPGR. Bottom row arrows point to the needle induced artifacts. The artifact is most obstructive in bSSFP compared to the other sequences.*

**References:** [1] G Gaffke, et al., Rofo 2005. [2] BA Hargreaves, JMRI 2012. [3] KL Miller, et al., Imaging in Medicine 2011. [4] EM Haacke, et al., Radiology 1990. [5] T Penzkofer, et al., CIRSE 2013.

**Table 1**
**Artifact Needle Tip Error and Width for Respective Sequences with Inconel Needle Inserted 5cm**

| Pulse Sequence | Tip Error (mm) | Width (mm) |
|---|---|---|
| bSSFP | 2.48 ± 0.90 | 9.77 ± 2.46 |
| iSSFP | 1.44 ± 0.89 | 9.44 ± 2.30 |
| GRE | 2.08 ± 1.18 | 9.62 ± 2.32 |
| SPGR | 2.09 ± 1.17 | 9.52 ± 2.37 |