

Frequency Adjustments in TIDE bSSFP Imaging to Compensate for Banding Artifacts Caused by Dental Braces

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Introduction

Metallic implants caused image artifacts like in-plane distortion and T_2^* -related signal loss when MRI examination is performed [1]. As discovered in our preliminary studies that when dental braces were present, images acquired with the transition into driven equilibrium balanced steady-state free precession (TIDE bSSFP) technique show banding-pattern artifacts, but the in-plane distortion is much less severe than that in the turbo-spin echo (TSE) images. Also from the findings in the TIDE phase images, it is inferred that the signal loss is likely a product of the inherent off-resonance suppression mechanism since there were continuous phase drifts rather than random phases [2, 3]. Therefore in this study, we applied system frequency adjustment to further validate this hypothesis, and we also used several post-processing methods to combine the images acquired at various system frequencies, in hope to obtain an artifact-minimized rendered image.

Materials and Methods

A 23 year-old woman wearing dental braces participated in this study, which had been approved by the institutional review board. Axial head images were acquired with a 1.5T MR system (Siemens Vision Plus, Erlangen, Germany). TIDE bSSFP sequence was used to imaging the subject with frequency adjustments of 0Hz (no adjustment), 30Hz, 60Hz, 90Hz, 120Hz, 150Hz, and 180Hz. Other parameters were a field of view of 240×240 mm, a 4-mm slice thickness with a 6-mm inter-slice gap, a matrix size of 256×256 . TR and TE were 6.46/3.23 ms. TSE images of the same spatial parameters were also acquired for comparison. Post-processing methods including maximum intensity projection (MIP) [4], summed projection (SUM, i.e. average when normalized) [4], and root-mean-square (RMS, as in the CISS technique [5]) were applied to produce a rendered image.

Results

In Fig. 1, results of seven frequencies are demonstrated. The large bandings “move” as the system frequency is shifted, though there are some narrow bandings (anterior part of the head) that do not vary a lot. They are hence expected not to be remedied in the rendered images. In Fig. 2, the original TIDE images of 0, 150, and 180 Hz (3 frequencies) are displayed, as well as the rendered images using MIP, SUM, and RMS out of the 3 and 7 frequency-adjusted images. There are some banding residuals in the rendered images (red arrows), while among the three post-processing methods, the MIP results show a clear edge of these residuals.

Discussion and Conclusion

In this study, we have confirmed the signal loss as banding artifacts is a result of inherent off-resonance suppression like the one used in fat-suppressed TIDE, when the imaging planes are superior to the oral cavity (where dental braces are installed). However there are narrow bandings at the anterior region that cannot be addressed. This may result from a much steeper magnetic gradient since this region is closer to the oral cavity. Among the three methods, MIP shows a more homogeneous rendered image that resemble the original TIDE image if dental braces were not present, despite the clear-edged banding residuals. Seven frequency adjustments show a slightly better result than three frequencies for the MIP case, though the scan time is naturally lengthened.

Reference

1. Lu W, *MRM* 62: 66
2. Huang YC, *ISMRM* 2006 #633
3. Huang YC, *ISMRM* 2009 #867
4. Wallis J, *IEEE Trans Med Imag* 8: 297
5. Deimling M, *SMR* 1989 #403

Figure 2 Combining the TIDE images of 3 frequencies (0, 150, 180 Hz) or all 7 frequencies. The processing methods used here include maximum intensity projection (MIP), summed projection (SUM), and root-mean-square (RMS).

Banding residuals still occur, and MIP shows a clear edge (red arrows) while the other two methods show a broad and blurred hypointensity. Around the paranasal sinuses, the narrow bandings that do not change much when system frequency is shifted inevitably occur in the rendered images (orange arrow).

The TSE image at the same location is also demonstrated for comparison.

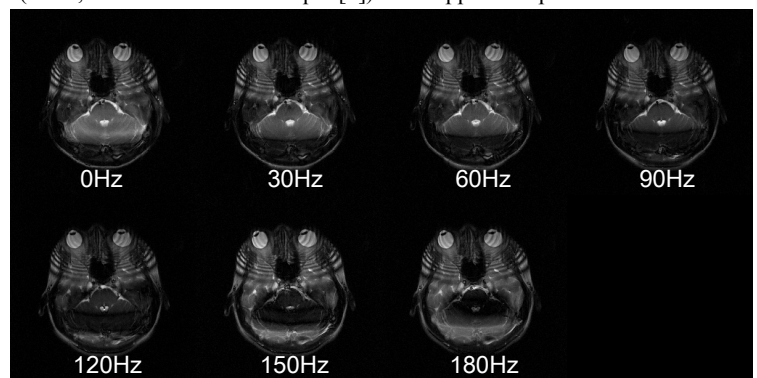
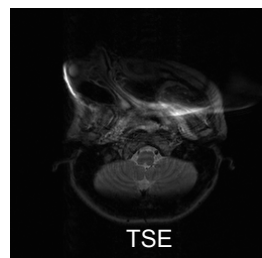


Figure 1 The TIDE images of the subject wearing dental braces under various system frequency settings. Some bandings do not vary with the frequency shift.

