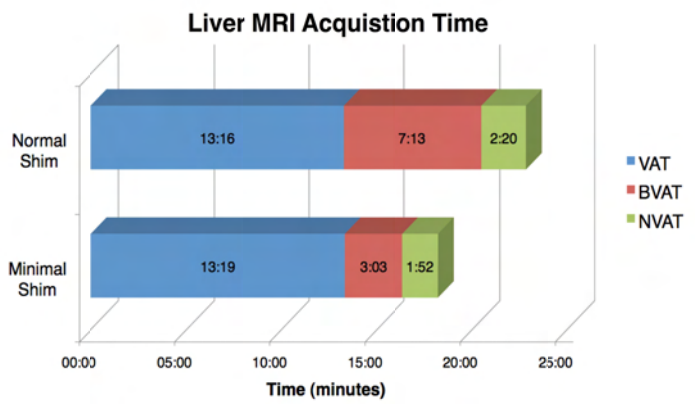
Repeated Shimming During MR Imaging of the Liver: Necessary Tool or Historic Relic?

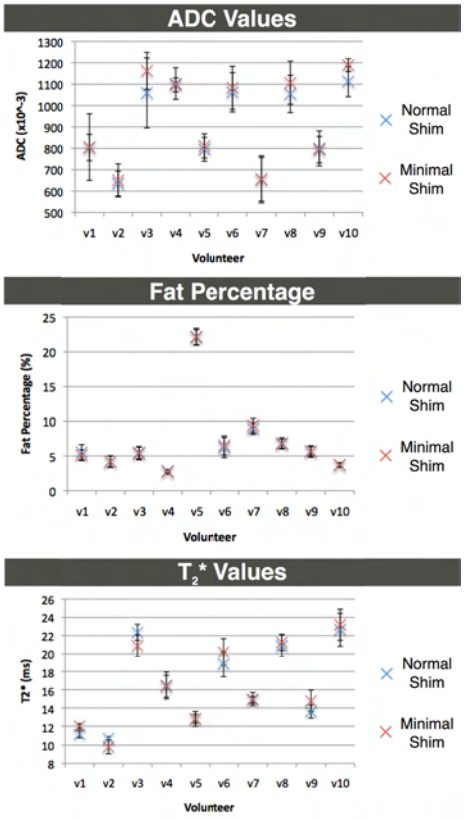
Mustafa Rifaat Bashir[1], Brian Marshall Dale[2], Rajan Tilak Gupta[1], Jeffrey J Horvath[1], Daniel Tobias Boll[1], and Elmar Max Merkle[1]
[1]*Radiology, Duke University Medical Center, Durham, NC, United States,* [2]*Siemens Medical Solutions, Cary, NC, United States*

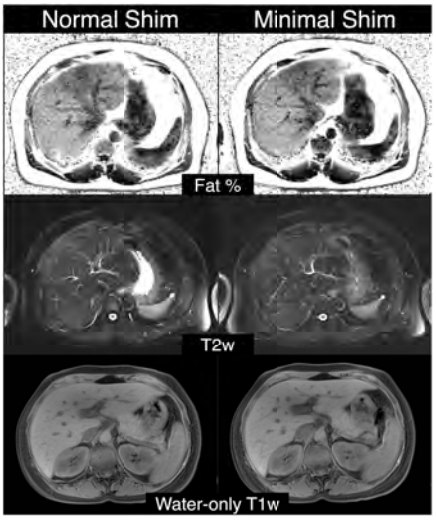
Purpose

One of the main criticisms of hepatic MRI (in contrast to CT) is scan time, both in terms of length and variability. In a small prospective study at a single center, table times in contrast-enhanced MRI of the liver were shown to vary from 19 up to 58 minutes, even when examinations were performed by an experienced technologist (1). In the same study, it was observed that the number of adjustments performed by the scanner prior to initiating a pulse sequence was higher when imaging the liver as compared with the knee, and that these adjustments contributed to total acquisition time. Shimming and adjustment steps are important to homogenize the magnetic field and provide optimal image quality (2). However, adjustment data can be carried forward from sequence to sequence under certain conditions, and some of the repeated adjustment steps may be unnecessary.

The purpose of this study is to assess whether an MRI protocol which minimizes repeated preparatory adjustments, in particular shimming, can save scan time while maintaining image quality.







Materials and Methods

This prospective Health Insurance Portability and Accountability Act–compliant study was approved by our institutional review board. Ten volunteers (5 men, 5 women, age 38.9 +/- 4.9) underwent two noncontrast liver MRI protocols on a single 3 T MRI system, with all scans performed by a single technologist. The protocols were identical except that one was optimized to reduce the number of adjustments, in particular reshimming, by fixing the table position and allowing maximum tolerances for carrying adjustment data forward from one sequence to the next ("minimal shim" protocol); the other protocol used standard manufacturer-set adjustment settings ("normal shim"). Continuous video screen capture of the graphic user interface of the MRI console was recorded and analyzed using the Lean Six Sigma framework, with Value Added Time (VAT) defined as image data acquisition time, Business Value Added Time (BVAT) as scanner preparatory time, and Non-Value Added Time (NVAT) as time the scanner was not active (image setup, breathing instructions, etc.) (1). Differences in acquisition time were evaluated using a paired Student's t-test.

Quantitative measurements derived from image data (ADC, fat percentage values, and T2* values) were analyzed for differences due to patient differences, test noise, ROI location, and shim status (use of the minimal or normal shim protocol) using ANOVA and variance components analysis. Two expert readers with 14 and 3 years post-fellowship experience in abdominal MRI independently assessed image data from the two protocols side-by-side (blinded to which images were obtained with which protocol) and were asked to indicate a preference for either data set, for each sequence in each examination, and mean differences tested using ANOVA.

Results

Use of the minimal shimming protocol resulted in a 58% reduction in BVAT (3:03 vs. 7:13; $p < 0.001$) and a 20% reduction in total scan time (18:13 vs. 22:48; $p < 0.001$). There were no significant differences in the subjective assessment of image quality ($p = 0.174$-1.0). Differences in quantitative measures due to shim status were not statistically significant ($p = 0.201$-0.962). Shim was a minor contributor to total variance (0.03%-0.3%) compared to volunteer differences (76.5%-97.3%), random noise (2.5%-22.0%), and ROI location (0.1%-1.2%).

Conclusion

This volunteer study shows that minimizing prescan preparatory adjustments can reduce total scan time in MRI of the liver without altering image quality. Further work is needed to show whether these time savings can be realized in clinical MR imaging of patients.

References

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2. Schar M et al. Magn Reson Med 2010 Feb;63(2):419