B0 SHIMMING FOR MAGNETIC RESONANCE SPECTROSCOPY AND SPECTROSCOPY IMAGING

The accurate assessment of brain metabolites using Magnetic Resonance Spectroscopy and Spectroscopic Imaging (MRS/MRSI) plays a crucial role in various clinical and research applications. Furthermore, the precise quantification of brain metabolites provided by MRS/MRSI aids in the early detection of diseases and helps guide personalized treatment strategies. An illustrative clinical study demonstrated the remarkable performance of MRS, with sensitivity (82.60%), specificity (85.71%), and accuracy (100%), in effectively distinguishing neoplastic from non-neoplastic brain lesions [1].

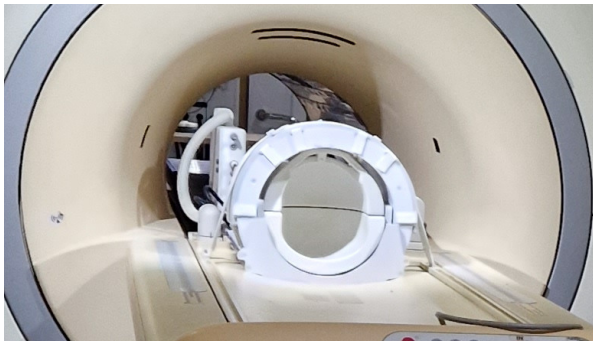
However, obtaining high-quality spectroscopy data in challenging body regions, such as the **basal and frontal region of the brain** or regions **close to air cavities**, remains a significant technical challenge. Furthermore, MR spectroscopy benefits greatly from higher MRI field strengths but the problem only exacerbates at these field strengths. In large scale studies sometimes **more than 30%** of the acquired data has to be discarded due to low quality spectra that does not pass the quality assurance.

In this white paper, we present a case study aimed at improving spectroscopic data quality leveraging the advanced capabilities of the *Elara* local shim system.

In large scale clinical studies a significant proportion, sometimes exceeding 30%, of the MRS(I) data has to be discarded due to sub-optimal quality.

Innovative Technology

The *Elara* local shim system for brain imaging [2] is a **modular local** shim array designed specifically for optimizing magnetic field homogeneity in brain imaging. Compared to the scanner shims, local shim coils provide a higher degree of spatial specificity in magnetic field adjustments. By placing these coils in close proximity to the region of interest, they can generate localized magnetic field corrections. This targeted approach allows for more precise and efficient shimming. Additionally, local shim coils offer increased flexibility in adapting to different anatomical structures.



24-ch Elara shim array mounted on the head RF coil

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This cutting-edge system is carefully tailored to the user's RF setup, ensuring seamless mechanical integration. The system can be flexibly configured to suit specific imaging requirements. This modular design ensures maximum flexibility and adaptability to different imaging scenarios.

Installation of the Elara local shim system is straightforward and user-friendly. Using a positioning guide the light-weight setup can be easily mounted and removed.

The system comes with all necessary amplifiers and peripherals, ensuring a seamless integration process with existing MRI systems. To achieve optimal magnetic field performance, the Elara local shim system utilizes advanced shim algorithms. These algorithms are specifically designed to address the challenges associated with cavities as well as small and ill-conditioned regions in brain imaging (such as single voxels) resulting in enhanced B0 field homogeneity and improved image quality.

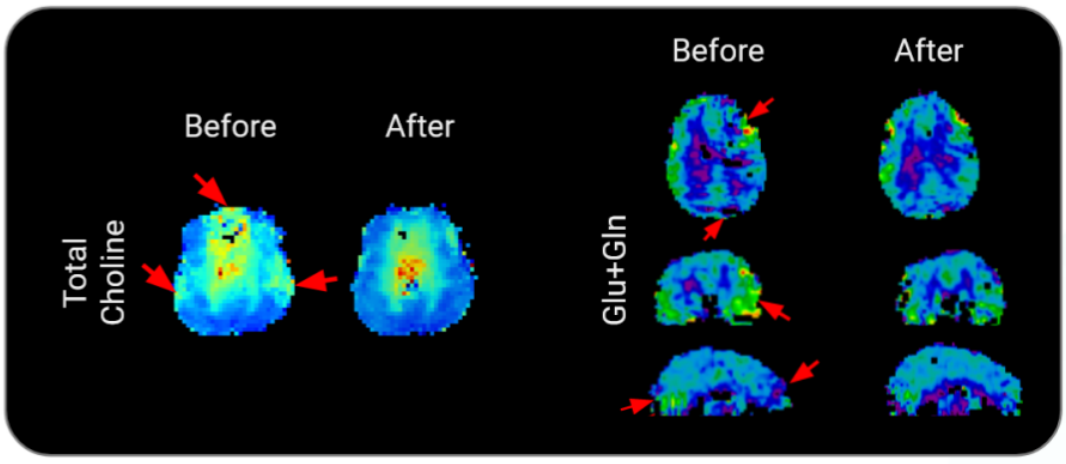
Case Study

Two investigational case studies are presented to assess the effectiveness of the Elara local shim system in improving field homogeneity and enhancing the quality of metabolite maps in challenging brain regions.

In the first study [3] a Siemens Terra [4] 7T MRI scanner equipped with a 1Tx/32Rx NOVA [4] head RF coil was utilized. The MRSI acquisition employed a 3D FID 1H MRSI concentric ring sequence, ensuring whole-brain spatial coverage while minimizing acquisition time. Spectral fitting was performed using LCMODEL [4]. The matrix size was set to 64x64x39, providing a high spatial resolution of 3.4mm isotropic. An acquisition delay of 1.3 ms and a repetition time (TR) of 450 ms were chosen.

The vendor-provided 2nd order spherical harmonics shims were used in the study and MRSI data was acquired both with and without the Elara 24-channel shim systems.

The resulting whole-brain MRSI maps obtained demonstrated consistent improvements in field homogeneity, particularly in challenging brain regions such as the basal and frontal lobes. Notably, the basal lobes exhibited a remarkable enhancement of **30%**, while the frontal lobes showed a substantial improvement of **22%**. These improvements in field homogeneity contributed to increased anatomical fidelity and the overall quality of the metabolite maps. Additionally, the reliable metabolite fits, aided by the enhanced field homogeneity, resulted in lower Cramér-Rao lower bounds (CRLBs). The decrease in CRLBs indicates improved accuracy and precision in metabolite quantification, enabling more reliable and robust interpretation of the acquired data.



Brain metabolite mapping using 1H MRSI at 7T before and after using the local shim array:
Better gray / white matter delineation and more voxels recovered in tCholine and Glu+Gln maps

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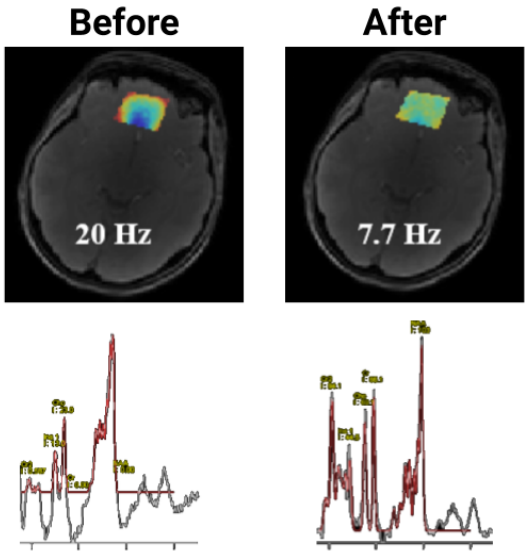
In the second study, a Siemens Prisma 3T MRI scanner equipped with a 32-channel head-neck coil was employed. The study focused on single voxel STEAM spectroscopy in the prefrontal cortex, a challenging region known for B0 field inhomogeneity. The vendor-provided 2nd order spherical harmonic shims were used and field amps as well as single-voxel spectroscopy data was acquired with and without an 8-ch Elara™ shim system tailored to the aforementioned head RF coil.

The use of the advanced shim system resulted in a significant **60%** reduction in field inhomogeneity. The acquired spectra exhibited improved line-width and peak separation, indicating enhanced spectral quality.



Single voxel field maps and spectro in the frontal cortex
Improved linewidth and peak separation

With significant improvement in field homogeneity in challenging anatomical areas (30% in basal region, 60% in single voxel frontal region) more reliable quantification of metabolites and sharper linewidths are achieved.

Conclusion

The presented investigations demonstrate the effectiveness of the local shim system in improving field homogeneity and enhancing the quality of spectra in challenging anatomical regions. The system's application resulted in substantial improvements in field homogeneity, increased accuracy and precision in metabolite quantification, and enhanced spectral quality. These findings highlight the potential of the Elara local shim system to positively impact spectroscopy studies and improve the reliability and interpretation of acquired data.

[1] Alshammari, Qurain T et al. "Accuracy of Magnetic Resonance Spectroscopy in Discrimination of Neoplastic and Non-Neoplastic Brain Lesions." Current medical imaging vol. 17,7 (2021): 904-910.

*[2] **CAUTION**: Not a medical device. Limited by Federal (or United States) law to investigational use.*

[3] Lazen P, et al., "Improving the B0 homogeneity in 7 T MRSI applications using a 24-channel local array of shim coils", Proc. Intl. Soc. Mag. Reson. Med. 29 (2021)

[4]All product and company names are the registered trademarks of their original owners. The use of any trade name or trademark is for identification and reference purposes only

The local shim systems offered by MR Shim are customizable to any MRI setup or anatomical region.
Learn more by visiting our website or contact us today to schedule a meeting

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