Optimizing Temporomandibular Joint MRI Using Deep Resolve with the UltraFlex Large 18 Coil

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Introduction

Magnetic resonance imaging (MRI) is the reference modality for assessing temporomandibular joint (TMJ) disorders because of its excellent soft tissue contrast and ability to depict the articular disc, condyle, retrodiscal tissues, and bone marrow. High spatial resolution is essential for the accurate evaluation of these small and complex anatomical structures, but it traditionally comes at the expense of longer acquisition times and reduced patient comfort [1].

In a previous MAGNETOM Flash article, we demonstrated how the UltraFlex Large 18-channel coil enables a comfortable, high signal-to-noise (SNR) workflow for TMJ imaging [1]. The introduction of Deep Resolve represents the natural evolution of that protocol. While Deep Resolve Boost (DRB) increases the effective SNR through AI-based denoising, Deep Resolve Sharp (DRS) enhances edge definition and perceived spatial resolution, allowing improved visualization of fine anatomical details. Their combined use provides additional flexibility during protocol optimization, enabling the available SNR to be redistributed toward shorter acquisition times, higher spatial resolution, or an optimal balance between the two [2].

The aim of this work was to optimize a routine TMJ MRI protocol by combining the UltraFlex Large 18-channel coil with Deep Resolve technologies on a 1.5T MAGNETOM Sola Fit, with the objective of improving diagnostic image quality while maintaining a clinically feasible examination time.

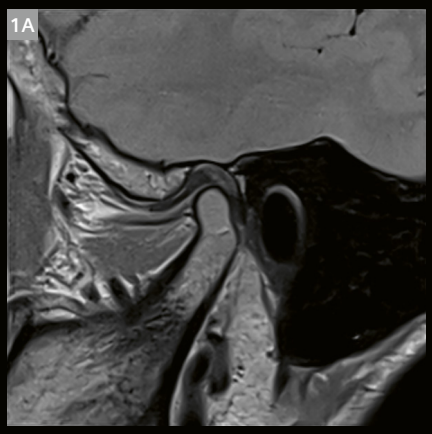
Methods

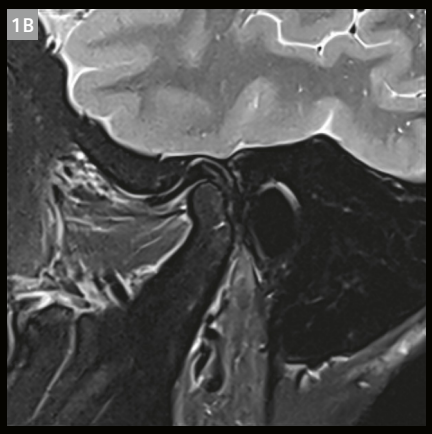
All examinations were performed on a 1.5T MAGNETOM Sola Fit running *syngo* MR XA70 software at the Centro Medico Specialistico (CEMS) in Verona, Italy. The patient positioning and the UltraFlex Large 18-channel coil configuration described in our previous work were maintained, preserving the advantages of high SNR, positioning flexibility, and patient comfort [1].

In this study, protocol optimization focused on the acquisition of sagittal proton density-weighted (PD), sagittal T2-weighted fat-suppressed (T2 FS) (Fig. 1), coronal T1-weighted, and axial T1-weighted turbo spin echo (TSE) sequences (Fig. 2). A T1-weighted TSE fat-saturated image (Fig. 3) was added as an option for contrast medium examinations. However, the same reconstruction strategy can be extended to any additional sequence or imaging plane required by the clinical indication.

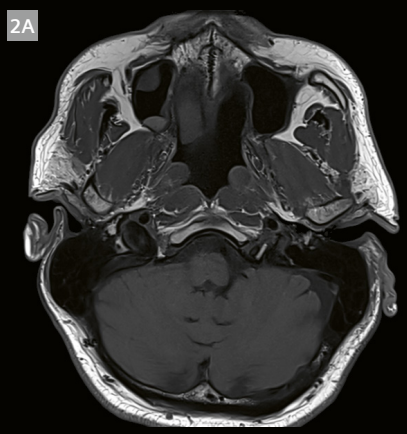
High-resolution TSE images were reconstructed using Deep Resolve Boost with medium denoising, which was increased to high denoising for selected acquisitions. Deep Resolve Sharp was enabled throughout the protocol.

From a protocol optimization perspective, Deep Resolve Boost and Deep Resolve Sharp are two complementary yet independently adjustable reconstruction components. Deep Resolve Boost primarily improves effective SNR by suppressing image noise, whereas Deep Resolve Sharp enhances spatial detail and edge definition. Consequently, the reconstruction can be optimized according to the clinical objective: to reduce acquisition time while maintaining image quality, to improve spatial resolution within the same acquisition time, or, more commonly, to achieve a balanced compromise between these two goals.



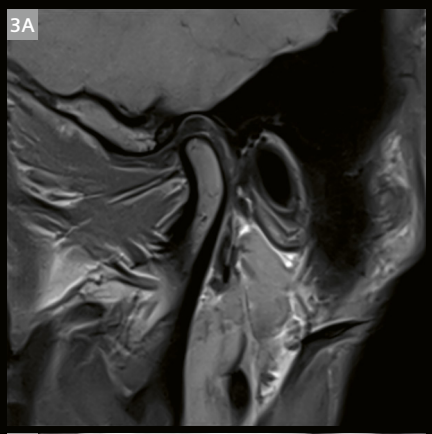


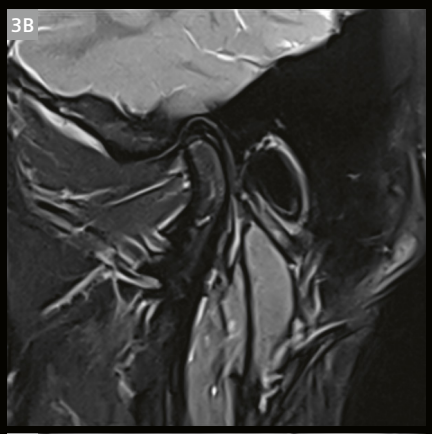
1 PDw TSE **(1A)** and T2w TSE FS **(1B)** in sagittal orientation. Images acquired with the UltraFlex Large 18 coil, Deep Resolve Boost and Sharp, and 1.6 mm slice thickness. Standard protocol.

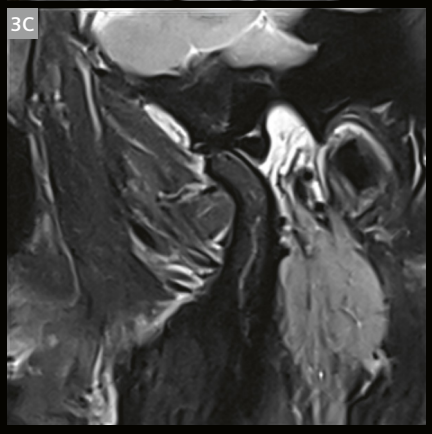


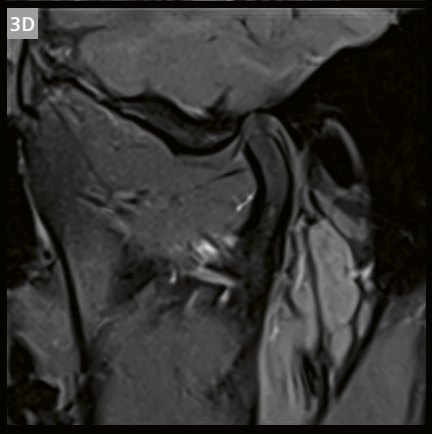


2 T1w TSE in transversal **(2A)** and coronal **(2B)** orientation. Slice thickness 3 mm **(2A)** and 2 mm **(2B)**. Standard protocol.

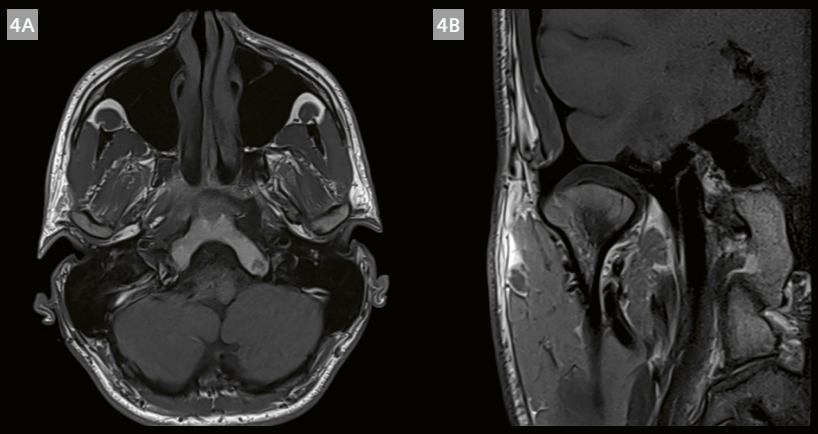




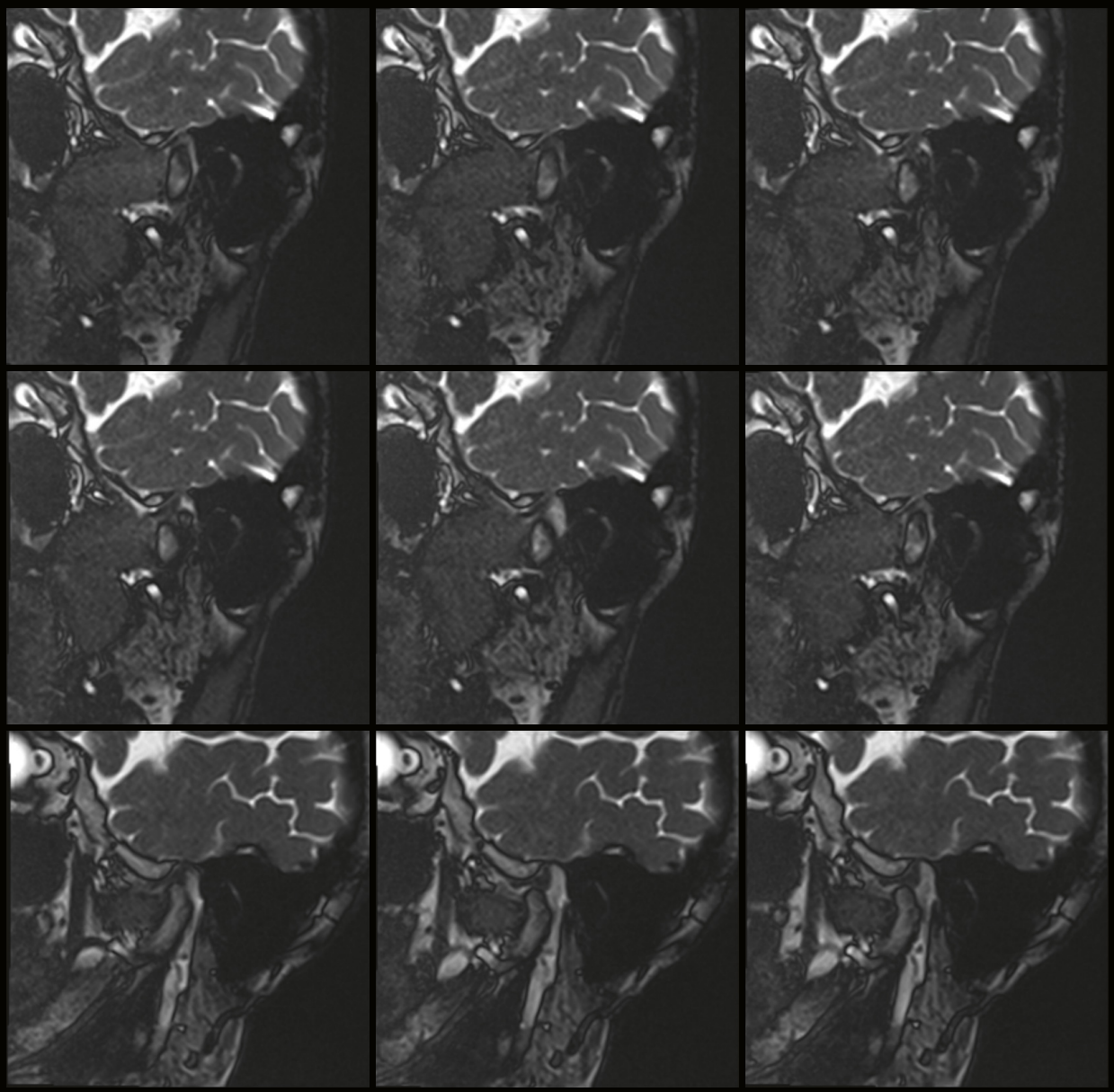




3 PDw TSE closed mouth **(3A)**, T2w TSE FS closed **(3B)** and open **(3C)** mouth, and T1w TSE FS closed mouth **(3D)** in sagittal orientation. Images acquired with the UltraFlex Large 18 coil, Deep Resolve Boost and Sharp, and 2 mm slice thickness. Fast protocol.



4 T1w TSE in transversal **(4A)** and coronal **(4B)** orientation. Slice thickness 2 mm with open mouth **(4A)**, 3 mm **(4B)**. Fast protocol.



5 Dynamic sagittal cine TrueFISP images during mouth opening and closing.

The UltraFlex Large 18-channel coil complements this approach by providing high intrinsic SNR and excellent spatial separation between coil sensitivity profiles, enabling the use of higher GRAPPA acceleration factors with limited SNR penalty. The combination of a high-density receiver array, parallel imaging, and AI-based reconstruction is therefore an effective strategy for optimizing high-resolution TMJ imaging.

A dynamic TrueFISP (TRUFI) sequence was additionally incorporated for the assessment of TMJ kinematics during mouth opening and closing (Fig. 5). Although this sequence does not benefit from AI reconstruction, it fully exploits the high SNR provided by the UltraFlex Large coil, resulting in excellent temporal and spatial image quality.

Results

The optimized protocol successfully combined high spatial resolution with clinically feasible acquisition times. Routine acquisitions were performed using 1.6 mm slice thickness for both conventional and fat-suppressed sagittal sequences with an 80 mm field of view, achieving DRS-interpolated in-plane resolutions of approximately 0.2 × 0.2 mm^2 for PD-weighted images and 0.3 × 0.3 mm^2 for fat-suppressed acquisitions. Despite this high spatial resolution, individual acquisition times remained consistently below 2 minutes and 30 seconds (Table 1), (Figs. 1, 2, 5).

Deep Resolve Sharp produced a noticeable improvement in edge definition, whereas Deep Resolve Boost reduced image noise while preserving tissue contrast. Together, these technologies improved the visualization of the articular disc, retrodiscal tissues, cortical bone margins, mandibular condyles, and surrounding osseous structures. The increased spatial resolution also facilitated the assessment of clinically relevant findings, including subtle disc displacement, early internal derangement, small cortical erosions, bone marrow signal abnormalities, joint effusion, and early degenerative changes.

The protocol also enabled the routine acquisition of complementary axial and coronal TSE sequences with 3 and 2 mm slice thickness in less than one minute, providing additional functional and anatomical information without substantially increasing the total examination time.

An additional advantage of the optimized workflow was the flexibility offered by AI reconstruction. At equivalent spatial resolution, acquisition times could be reduced by approximately 50% compared to non-AI protocols. Alternatively, the same examination time could be reinvested to obtain thinner slices and higher spatial resolution, depending on the clinical question.

Overall, the shorter acquisition times improved patient comfort and examination tolerance, particularly during mouth-open imaging, where prolonged acquisitions frequently increase the likelihood of motion artifacts. Consequently, the optimized workflow not only improved image quality but also enhanced the robustness and reproducibility of TMJ MRI in routine clinical practice.

In addition to the high-resolution protocol, a second workflow was developed specifically for high-throughput routine clinical practice. By moderately reducing the in-plane spatial resolution, increasing the sagittal slice thickness from 1.6 mm to 2 mm, and using a GRAPPA acceleration factor of 4, a complete TMJ MRI examination could be performed in 8 minutes and 4 seconds (Table 2), (Figs. 3, 4).

Sequence	Orientation	FOV [mm]	Base resolution	Phase resolution	Slice thickness [mm]	TR [ms]	TE [ms]	iPAT factor	Scan time [min:sec]
T1w TSE	Transversal	190 × 190	640 (DRS interpolated)	100	3	626	12	3	00:27
PDw TSE	Sagittal (2 slice groups)	80 × 80	352 (DRS interpolated)	100	1.6	3430	11	3	02:00
T2w TSE fs	Sagittal (2 slice groups)	80 × 80	320 (DRS interpolated)	100	1.6	5850	66	3	02:16
T1w TSE fs	Sagittal (2 slice groups)	80 × 80	256 (DRS interpolated)	100	1.6	545	11	3	02:28
T1w TSE	Coronal (2 slice groups)	100 × 100	512 (DRS interpolated)	80	2	661	11	4	01:19
Cine Trufi	Sagittal (2 slice groups)	120 × 120	256 (zero-filling interpolated)	100	3.5	570.84	2.13	2	01:15 with 65 phases

Table 1: Main acquisition parameters for the standard protocol

Sequence	Orientation	FOV [mm]	Base resolution	Phase resolution	Slice thickness [mm]	TR [ms]	TE [ms]	iPAT factor	Scan time [min:sec]
T1w TSE	Transversal	190 × 190	608 (DRS interpolated)	80	3	626	12	4	00:17
PDw TSE	Sagittal (2 slice groups)	80 × 80	352 (DRS interpolated)	100	2	2910	11	4	01:01
T2w TSE fs	Sagittal (2 slice groups)	80 × 80	320 (DRS interpolated)	100	2	4740	63	4	01:22
T1w TSE fs	Sagittal (2 slice groups)	80 × 80	224 (DRS interpolated)	100	2	461	10	3	01:27
T1w TSE	Coronal (2 slice groups)	100 × 100	480 (DRS interpolated)	80	3	582	11	3	00:40
Cine Trufi	Sagittal (2 slice groups)	120 × 120	256 (zero-filling interpolated)	100	3.5	570.84	2.13	2	01:15 with 65 phases

Table 2: Main acquisition parameters for the fast protocol

Despite the increased acceleration, the combination of the UltraFlex Large 18-channel coil and Deep Resolve reconstruction preserved diagnostic image quality while substantially reducing overall examination time. This protocol is an attractive option for routine clinical imaging, particularly in high-volume departments where examination efficiency is essential.

Conclusion

The combination of the UltraFlex Large 18-channel coil and Deep Resolve represents a significant advancement in TMJ MRI. The high intrinsic SNR provided by the flexible coil, together with AI-based reconstruction, enables imaging protocols to be tailored to specific clinical needs by balancing spatial resolution and acquisition time.

Using this approach, routine TMJ MRI can achieve sub-millimetric in-plane resolution with 1.6 mm sagittal slices and acquisition times below 2 minutes and 30 seconds per sequence, while maintaining excellent image quality and patient comfort. Alternatively, a streamlined protocol enables a comprehensive TMJ examination to be completed in just 8 minutes and 4 seconds without compromising diagnostic confidence.

These results demonstrate how the combination of high-density receiver technology and AI-based reconstruction expands the flexibility of TMJ MRI, allowing imaging protocols to be optimized for either maximum anatomical detail or greater workflow efficiency, while maintaining high diagnostic performance.

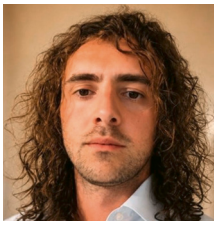
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