Case study 4: Deep Resolve Boost in lumbar spine imaging on Siemens Sola (XA51)

Dr Matthew Birkbeck, Newcastle upon Tyne NHS Foundation Trust

Introduction

This work was carried out at the Newcastle upon Tyne NHS Foundation Trust (NUTH) at the Freeman Hospital which is a tertiary referral centre. The protocol chosen to be optimised using the new deep resolve software was our routine diagnostic lumbar spine protocol. This work is preliminary as we move towards securing more time on the scanners to complete the optimisation work.

We aimed to reduce the scan time by approximately 50 % and observe if we could gain any improvement in image quality.

Methods – Staffing, Scanner and Sequence Information

Deep resolve boost is available on both of our 1.5 T Siemens Sola systems, both of which are at software version XA51. In this case study we evaluated the use of deep resolve boost and sharp and acceleration techniques to both improve image quality and reduce overall scan time per sequence. We currently have 1.5 whole time equivalent MRI Physicists working within NUTH. There is 1 MR Physicist who is leading on the implementation of deep resolve alongside a team consisting of 3 senior radiographers (one from diagnostic radiology, one from neuroradiology and one from radiotherapy physics). We chose to optimise the deep resolve sequences on one of the Sola scanners based in radiotherapy physics as this has dedicated research activity one day per week, and for lumbar spine sequences we have scanned 1 healthy volunteer.

Protocol Information and Scan Parameters

In our diagnostic lumbar spine protocol, we acquire: T2 and T1 weighted TSE sequences in both the sagittal and axial orientations and a STIR acquired in the sagittal orientation.

Table 1 shows the original diagnostic sequence parameters, including acquisition time.

Sequence Name	Field of View (mm)	Base Resolution	Phase Oversampling (%)	iPAT	Number of Signal Average	Repetition Time/Echo Time (ms)	Slice Thickness (mm)	Acquisition Time (mm:ss)
T2 turbo spin echo (sagittal)	310 x 310	384	80	GRAPPA: 2	2	3500/95	4	02:18
T1 turbo spin echo (sagittal)	230 x 230	320	100	GRAPPA: 2	2	603/9.4	4	03:12
STIR (sagittal)	310 x 310	320	90	GRAPPA:2	2	3500/48	4	04:10
T2 turbo spin echo (axial)	190 x 190	320	100	GRAPPA:2	2	7380/92	4	03:50
T1 turbo spin echo (axial)	200 x 200	256	100	GRAPPA:2	2	520/9.6	4	02:34

Table 1: Parameters from original diagnostic lumbar spine protocol.

Table 2 shows the sequences for the new protocol and their corresponding parameters, including acquisition time.

Sequence Name	Field of View (mm)	Base Resolution	Phase Oversampling (%)	iPAT	Number of Signal Average	Repetition Time/Echo Time (ms)	Slice Thickness (mm)	Acquisition Time (mm:ss)
T2 turbo spin echo (sagittal)	310 x 310	384	80	DRB: on DRS: on Denoising: high GRAPPA:4	2/1	3500/95	4	2 NSA: 01:18 1 NSA: 00:43
T1 turbo spin echo (sagittal)	230 x 230	320	100	DRB: on DRS: on Denoising: high GRAPPA:4	2/1	603/9.4	4	2 NSA: 01:09 1 NSA: 00:37
STIR (sagittal)	310 x 310	320	90	DRB: on DRS: on Denoising: high GRAPPA:4	2/1	3500/48	4	2 NSA: 02:14 1 NSA: 01:11
T2 turbo spin echo (axial)	190 x 190	320	100	DRB: on DRS: on Denoising: medium GRAPPA:4	2	7380/92	4	02:13
T1 turbo spin echo (axial)	200 x 200	256	100	DRB: on DRS: on Denoising: medium GRAPPA:4	2	520/9.6	4	01:24

Table 2: Parameters from diagnostic lumbar spine protocol with deep resolve boost and sharp applied.

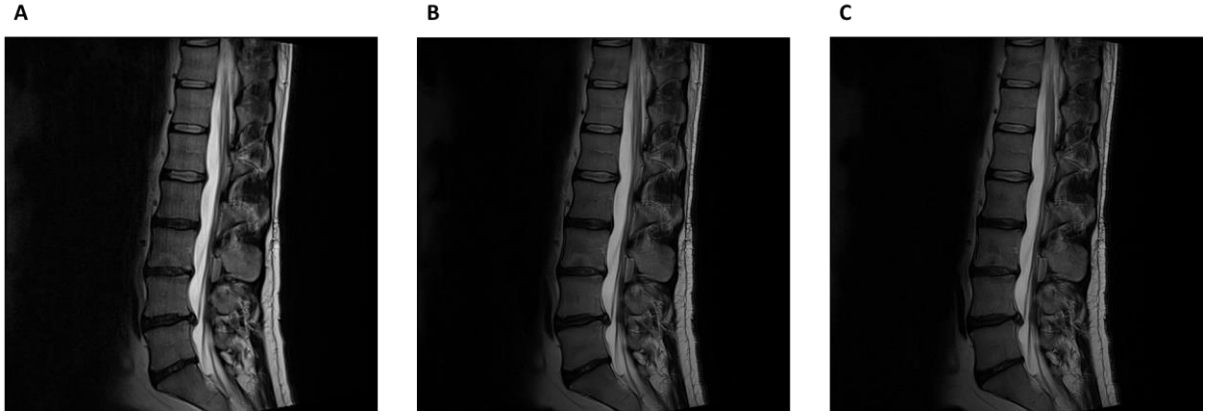
Results

Reduction in Overall Scan Time

Without deep resolve boost applied the original acquisition time of the lumbar spine protocol was 16 minutes and 4 seconds. We applied deep resolve boost and sharp in two ways: firstly, maintaining the number of signal averages at 2 per scan. This resulted in an overall acquisition time of 8 minutes and 18s, a reduction of 48 %. Secondly, we reduced the number of averages for the sagittal sequences only as the axial sequences acquired with 1 average were deemed too noisy, this resulted in overall acquisition time of 6 minutes and 8s, a reduction of 62 %. The first approach could be taken for a compliant patient and the second approach for an uncooperative patient in pain.

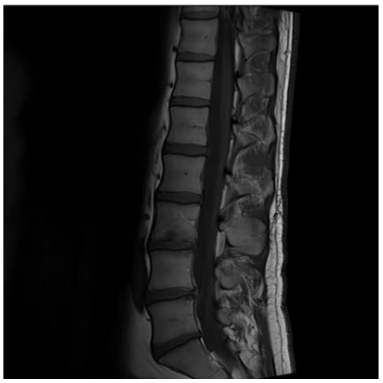
Image quality

Example images comparing both the original diagnostic image and the image with acceleration techniques applied are shown in figure 1.



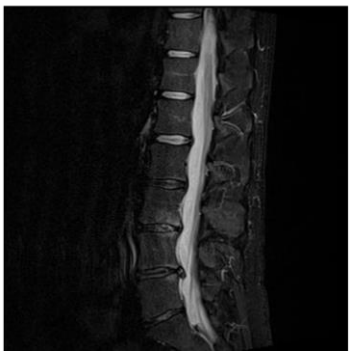
A

B



C

A



B

C

A

B

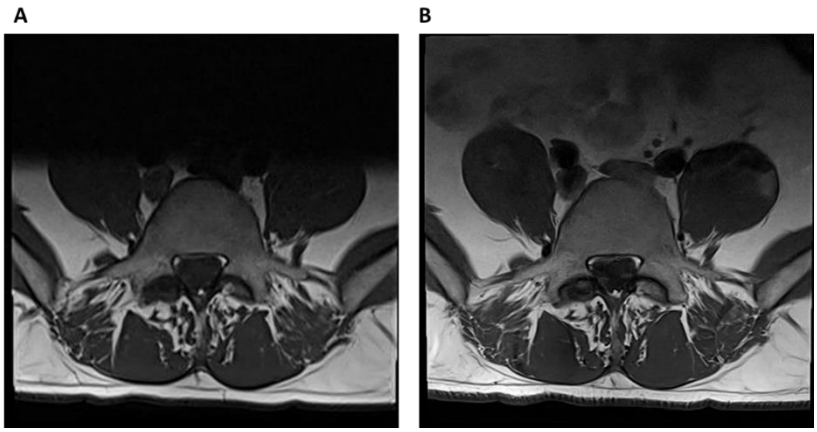


Figure 1: Panel 1: *A) Original sagittal T2 weighted TSE, B) sagittal T2w TSE with DRB and DRS with high denoising and GRAPPA factor 2 applied, C) sagittal T2w TSE with DRB and DRS with high denoising and GRAPPA factor 4 applied.* ***Panel 2:*** *A) Original sagittal T1w TSE, B) sagittal T1w TSE with DRB and DRS with high denoising and GRAPPA factor 2 applied, C) sagittal T1w TSE with DRB and DRS with high denoising and GRAPPA factor 4 applied.* ***Panel 3:*** *A) Original sagittal STIR TSE, B) sagittal STIR TSE with DRB and DRS with high denoising and GRAPPA factor 2 applied, C) sagittal STIR TSE with DRB and DRS with high denoising and GRAPPA factor 4 applied.* ***Panel 4:*** *A) Original axial T2w TSE, B) axial T2w TSE with DRB and DRS with medium denoising and GRAPPA 4 applied.* ***Panel 5:*** *A) Original axial T1w TSE, B) axial T1w TSE with DRB and DRS with medium denoising and GRAPPA 4 applied.*

Images were shown to an experienced radiologist who agreed that the image quality in the deep resolve boost acquisitions was no inferior to that of the original images, except in the axial T1 images which were degraded by artifact (see next section). The radiologist was also pleased with the uncooperative patient protocol as this is a significant time saving for patients who are in pain.

Artifacts

Some artifacts were noticed in the axial sequences for example in the T1 axial sequence there was apparent wrap artifact in the paraspinal muscles, show in in figure 2.

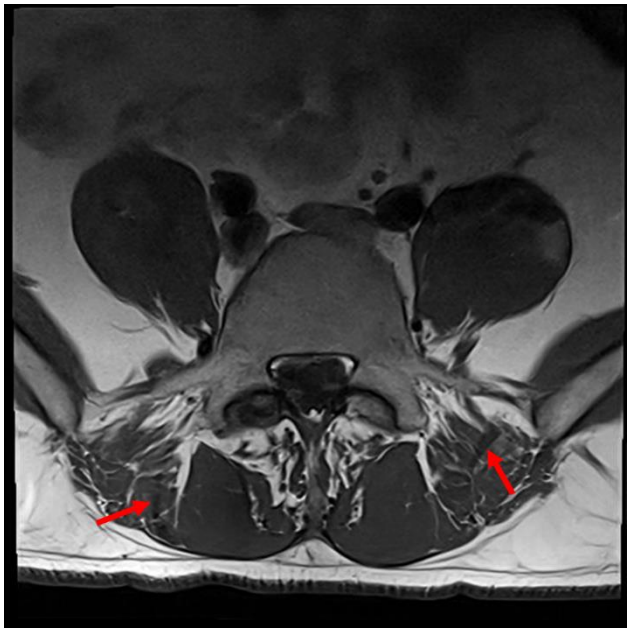


Figure 2: Wrap artifact indicated by the red arrows.

This could be resolved by either reducing the GRAPPA factor or by applying more phase oversampling to the sequence. This is going to be investigated as part of ongoing optimisation work for these sequences.

Conclusions and Future Work

We have successfully applied deep resolve boost and sharp to significantly reduce the acquisition time of the lumbar spine sequences. The reduction in acquisition time has also allowed us to develop protocols for both the cooperative and uncooperative patients. The axial images require further evaluation due to the presence of wrap artifact. The next steps include extending this work to other areas of the spine and whole spine imaging, and once the sequences are used in routine clinical imaging, we will assess how this has impacted the clinical service.