syngo TimCT – a Novel Concept for Whole-Body MRI

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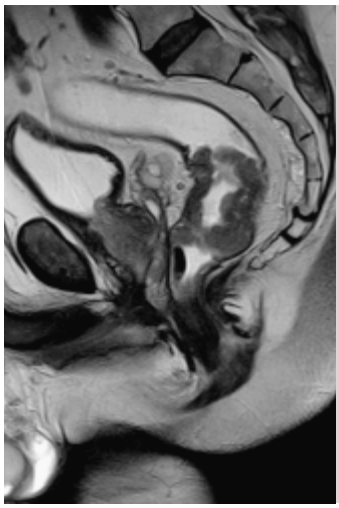
Introduction

The application of whole-body MRI for staging of malignant diseases is increasingly accepted by clinicians. Results underlining the diagnostic significance of the procedure are encouraging [1, 2]. Parallel imaging (iPAT), multiple Matrix coils and receiver channels (Total imaging matrix, Tim) opened the door for high-resolution whole-body MRI. The work of Fautz and Kannengiesser [3] formed the basis of the current clinical applications of the novel technique termed TimCT, which utilizes continuously moving table acquisition to generate images of excellent diagnostic quality. Thus, an extended volume coverage is now possible within one examination in order to gain information from organ systems distant from the primary region of interest to complete one-step staging or to significantly reduce examination time. Currently, we routinely perform TimCT for rectal cancer staging and follow-up of patients with Crohn's disease.

Technique

The purpose of Continuous Table Move MRI is to extend the field-of-view (FoV) in axial direction beyond the scanner's available scan region with a temporally and spatially seamless acquisition. The sliding multislice technique (SMS) was introduced in 2006 by Fautz et al. to minimize the required axial FoV without compromising image quality. The SMS uses a segmented multi-slice acquisition pattern, which samples the same phase-encoding step of any anatomical slice at the same spatial position in the scanner's axial FoV. The implementation of this special pattern avoids discontinuities between the images along the slice axis, for example, gradient non-linearity, because all z-dependent scan properties are encoded identically for all slices. The full k-space data of any slice is collected while the slice moves through the scanner from one scan position to the next (Continuous Table Move, CTM). The simultaneous acquisition of multiple slices is possible by just shifting the acquisition trajectories of different slices in time.

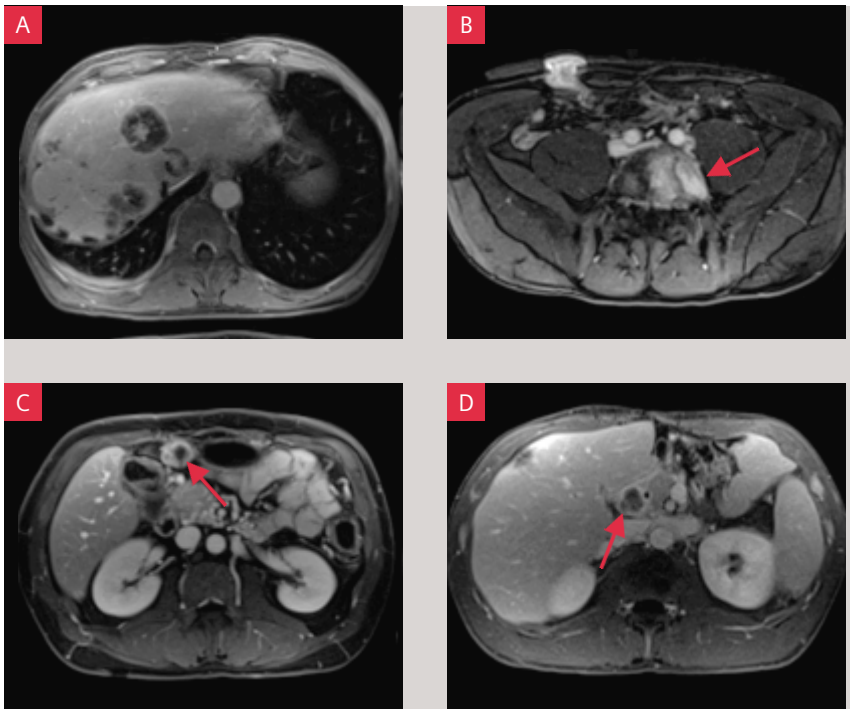
SMS implemented in the TimCT product can be applied to single-shot sequences (like FLASH) as well as to multi-shot sequences (like TSE). We now routinely perform a T1-weighted contrast-enhanced FLASH sequence with an initial breath-hold phase of 20 s to ensure artifact-free imaging of the liver and a free-breathing TIRM sequence. For both sequences the table speed is set to 1 cm per second. The sequence parameters are summarized in Table 1.



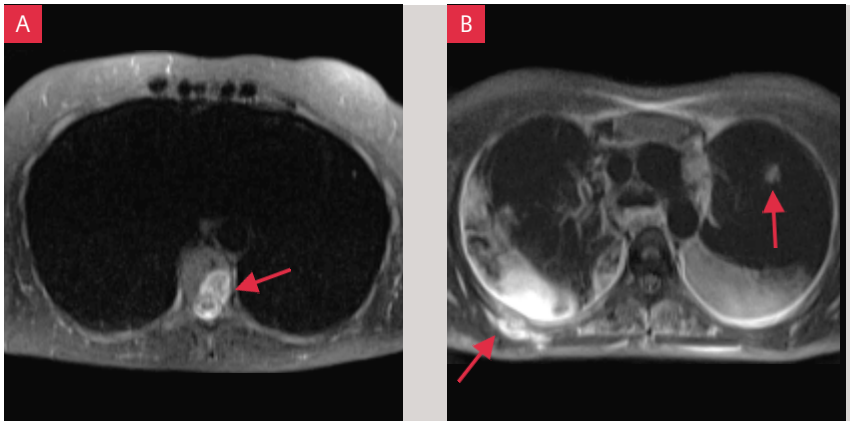
[Figure 1]
Example of T3 rectal cancer depicted on a sagittal T2-weighted TSE from our high-resolution pelvic MRI protocol.

Clinical applications

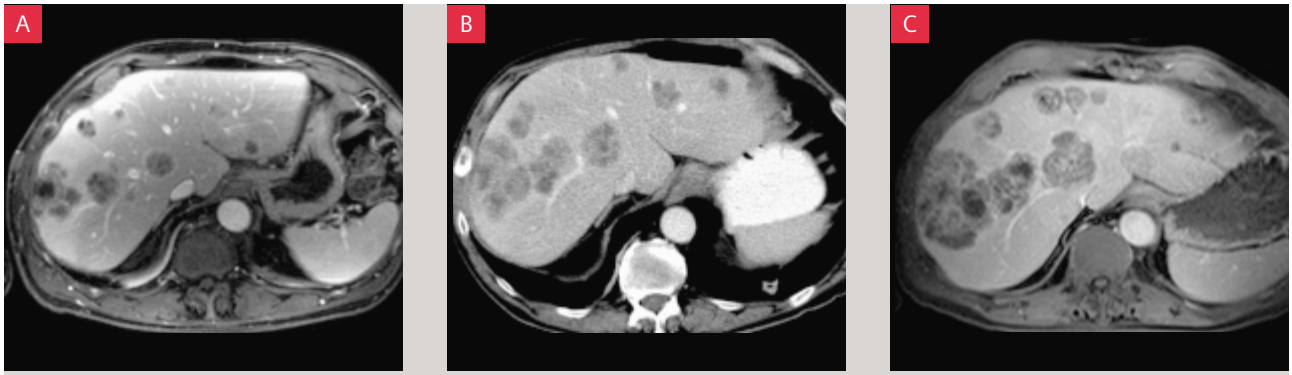
High-resolution pelvic MRI represents the current gold standard of local staging of rectal cancer [4]. No other state-of-the-art imaging modality has the ability to directly visualize the relationship between tumor and resection margin. To overcome step-by-step staging of rectal cancer patients using different imaging modalities, we integrated TimCT into a high-resolution imaging protocol for initial work-up and surveillance. With TimCT we perform both, an axial breath-hold contrast-enhanced T1-weighted FLASH sequence in a portal dominant phase to detect liver metastases and retroperitoneal lymph nodes, and an axial free-breathing TIRM sequence to cover the lungs, whole abdomen and pelvis to depict lung



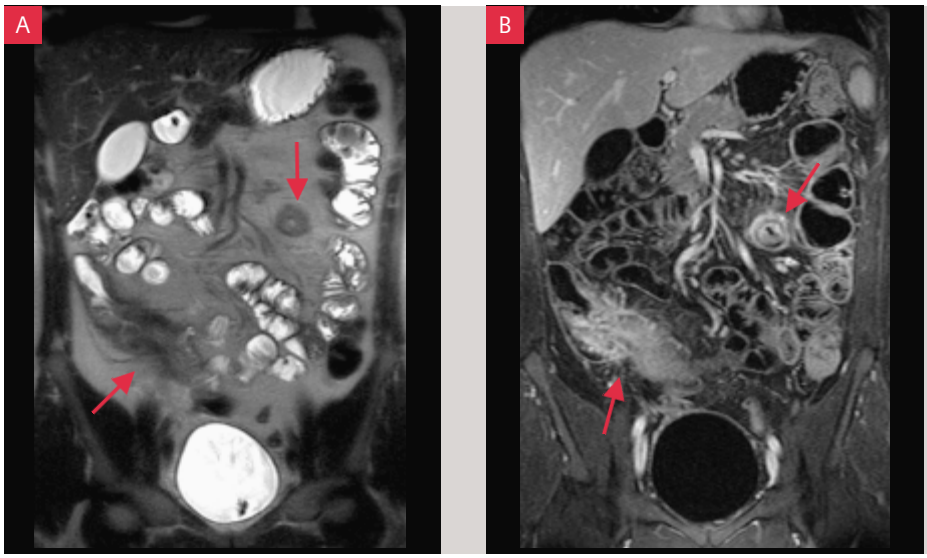
[Figure 2] *Axial TimCT FLASH images clearly visualize hepatic metastases (A), a bone metastasis in the 5th lumbar vertebra (B). Lymph node involvement in the transverse mesocolon (C) and the hepatoduodenal ligament (D).*



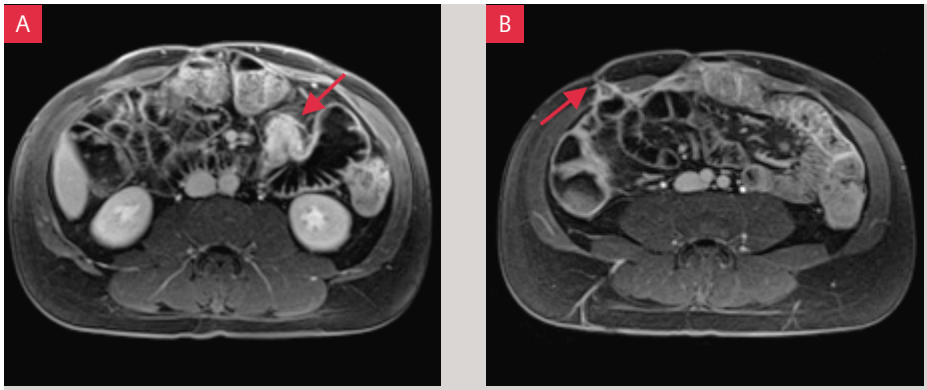
[Figure 3] *Axial TimCT TIRM images demonstrating metastasis in the thoracic spine (A), lung metastasis, rib metastasis and malignant pleural effusion (B) in patients with rectal cancer.*



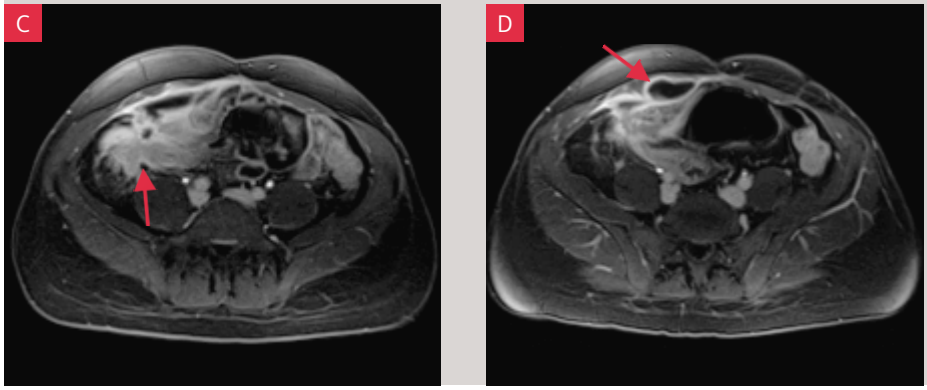
[Figure 4] *The comparison between (A) TimCT FLASH, (B) multi-slice CT and (C) conventional FLASH show the excellent lesion detection in this patient with recurrent rectal cancer and multiple metastases.*



[Figure 5] *Coronal HASTE (A) and contrast-enhanced VIBE (B) images derived from our Hydro-MRI protocol show manifestations of Crohn's disease with an inflammatory conglomerate and a skip lesion at the level of the proximal jejunum.*



[Figure 6] *Axial TimCT FLASH images of the same patient clearly demonstrate the skip lesion (A), an enterocutaneous fistula (B).*



The inflammatory conglomerate (C) and an abscess in the rectus abdominis muscle (D).

lesions, lymph nodes and bone marrow infiltration. Our experiences with TimCT for staging of rectal cancer patients are promising. The image quality has turned out to be comparable to that of a stationary upper abdomen protocol. Moreover, no differences in lesion detectability were found between TimCT and multi-slice CT (MSCT) regarding liver metastases and malignant lymph nodes.

MR-Enteroclysis is an established imaging technique for the evaluation of Crohn's disease since the degree of disease activity, presence of bowel wall pathology and extraintestinal manifestations of the disease (e.g. abscesses, fistulas) are accurately assessed [5]. For patient follow-up, Hydro-MRI is recommended by several working groups. Simplification and acceleration of the imaging protocol is of special interest, as

Crohn patients require repeated MRI during the course of the disease. However, the integration of Continuous Table Move MRI into a Hydro-MRI protocol for the evaluation of Crohn's disease has so far not been described. Our experiences with TimCT for the evaluation of patients with Crohn's disease are encouraging. The diagnostic sensitivity was found to be excellent compared to conventional axial multi-stage breath-hold sequences. Additionally, a marked reduction in total examination time can be achieved if TimCT is used.

Conclusion

syngo TimCT seems to be a promising adjunct to both rectal cancer staging and Hydro-MRI for follow-up of patients with known Crohn's disease. Scan efficiency and image quality are attributes of this upcoming technique. Furthermore, this new imaging modality is applicable to short-bore scanners like MAGNETOM Espree. In our opinion TimCT represents the next milestone in the evolution of whole-body MRI.

Prof. M. Langer, M.D. (left), O. Schaefer, M.D. (right)

Table 1: Sequence parameters for *syngo* TimCT

	TimCT-FLASH	TimCT-TIRM
TR	102 ms	3568 ms
TE	2.03 ms	101.22 ms
Slice thickness	5.0 mm	6.0 mm
Matrix	320 x 224	320 x 200
FoV	350 x 263 mm	400 x 250 mm
Pixel bandwidth	300 Hz/pixel	445 Hz/pixel
Flip angle	70°	60°
Slices/package	17	8
No. of packages	5	16
Pixel size	1.4 x 1.1 x 5.0 mm	1.6 x 1.1 x 6.0 mm
Parallel imaging	GRAPPA, factor 2	
Acquisition time	1 min.	4 min.

References
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