

CAIPRINHA and SPACE – a Winning Combination

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Introduction

“MRI is, or is becoming, the medical imaging modality of choice in more and more diverse applications ...” [1].

Magnetic resonance imaging can be described as the success story of medical imaging mainly due to two characteristics: its harmlessness and its ability to manipulate contrast. However, the acquisition technique, which

is relatively slow, can be considered a limiting factor, inducing patient discomfort and patient motion. Furthermore, data acquired is mainly 2D.

Acquisition time acceleration has become a major target in these last few years, on the one hand to reduce examination time and, on the other hand, to make MRI accessible to patients suffering from pain and/or non-cooperative patients.

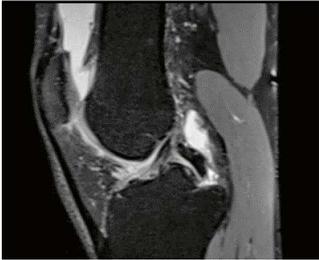
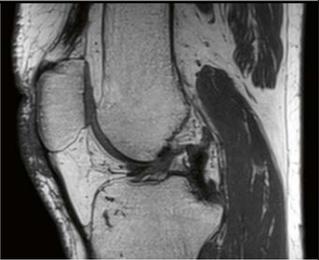
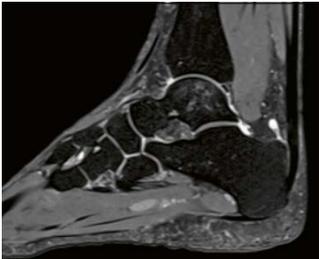
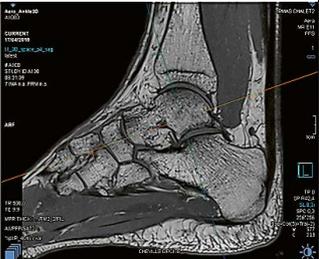
SPACE var T2 with fatsat	SPACE var T1	CAIPRINHA	Slice thickness (mm)	Voxel size R (mm)	Total TA min:sec Without adjustment
 TA 04:46	 TA 01:50	p4: 2 x 2	0.6	0.5 x 0.5 x 0.6	06:36
 TA 04:20	 TA 02:09	p4: 2 x 2	0.6	0.5 x 0.5 x 0.6	06:39
 TA 03:27	 TA 01:49	p4: 2 x 2	0.5	0.5 x 0.5 x 0.6	05:16

Table 1: It is now possible to perform a 3D MSK examination in less than 10 minutes including patient setup (in and out). SPACE with variable (var) flip angle mode for T1 and T2.

Several questions, however, remain:

- How can speed and diagnostic potential be combined? (The GOBrain protocol is the perfect answer to this question [2–4]).
- Is speed related to 2D acquisition? (Jan Fritz et al. propose GOKnee3D for efficient 3D imaging of the knee joint [5]).

GOKnee3D is the explosive combination, mixing SPACE acquisition technique (Sampling Perfection with Application optimized Contrasts using different flip angle Evolution) and the parallel imaging technique CAIPRINHA (Controlled Aliasing in Parallel Imaging Results in Higher Acceleration) [6, 7]. This protocol gives to radiologists the possibility to explore the knee joint in 3D without acquisition time constraints.

If this combination 3D and parallel imaging technique answers radiologists' expectations for the knee joint, it is justified to consider it for other body regions. We focused on the CAIPRINHA-SPACE evaluation for various body parts.

Method

Patients were examined with 1.5T MRI MAGNETOM Aera and 3T MAGNETOM Prisma. In our first step, we used the GOKnee3D for other body parts and compared it

with conventional 2D acquisitions as regards sensitivity and specificity for the targeted pathologies. We were immediately faced with the tough reality of MRI: tissue characteristics, coils (different g-factors), and protocol parameters (fatsat type, contrast type for SPACE: various proton density or T2 values) are different for each body region and it is necessary to revisit the CAIPRINHA-SPACE parameters to adapt to the anatomical region of interest. Detection of bone edema was a typical example.

To avoid testing the infinite possible combinations, we decided to use a SPACE with various T2 contrast parameters and add, when needed, other protocol parameters (fatsat mode, shim, etc.). This philosophy made it possible to combine our needs in terms of sensibility/specificity and an acceleration factor of 4 (2 x 2 using CAIPRINHA).

The main optimization strategy was focused on time reduction in 3D acquisition to enable its use in clinical routine without compromise on diagnostic potential.

The second step was to compare conventional SPACE to the new CAIPRINHA SPACE technique. Main body parts were studied on a 1.5T MRI system. Only the brain could also be studied on 3T, because our 3T system configuration does not include MSK coils. We use this 3T system exclusively for neurology.

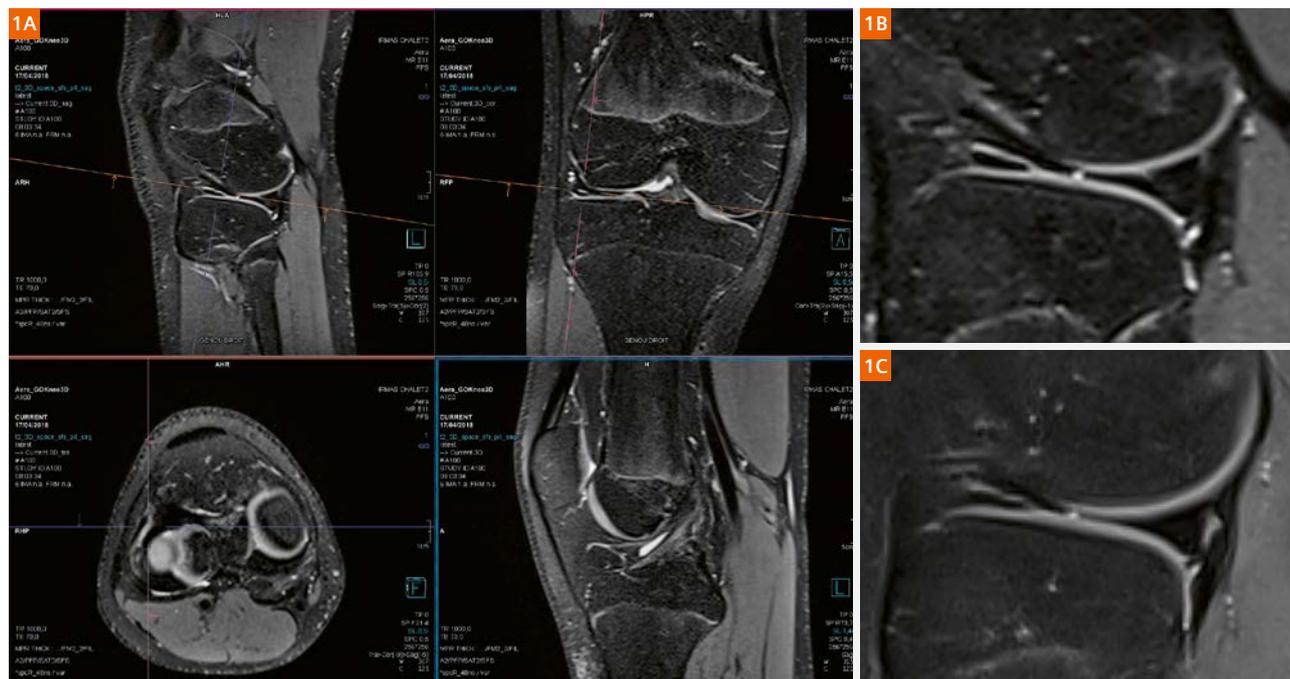


Figure 1: MPR reconstruction of 3D SPACE T2 fatsat (1A). Sagittal plane (1B) shows meniscus tear better than 2D (1C).

Optimizing MR acquisition and reducing scan times

MSK

Acquisition time reduction is significant. It is now possible to perform a 3D MSK examination in less than 10 minutes including patient setup (in and out) (Table 1). Two fast protocols, 3D T2 fatsat, and T1 are acquired. From a radiologist's perspective, it is no longer necessary to multiply acquisition planes and contrasts; it also avoids a situation in which you have to skip one plane or one contrast.

The multiplanar reconstruction (MPR) potential enables the radiologist to adapt to different patients and pathologies, in a similar approach to MSK in ultrasound (Fig. 1). Complex joint imaging, for example of the ankle or elbow, is facilitated (Figs. 2, 3).

Neurology

CAIPIRINHA SPACE really demonstrated its full potential in this application. It represents, for us, a solution to a major diagnostic challenge. It made it possible to examine in 3D, with a similar examination time compared to the time needed with our two protocols: brain and spine

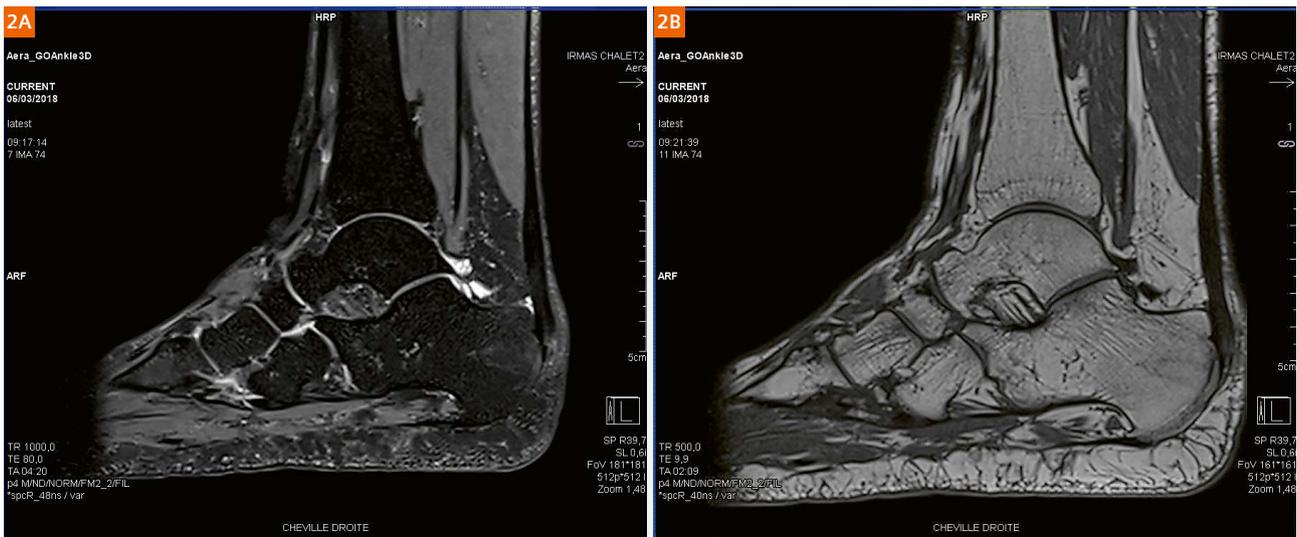


Figure 2: 3D T2 fatsat and T1 in the ankle. These two acquisitions, with MPR reconstructions of 0.6 mm nicely visualize the Achilles tendon and the bone reactions close to calcaneal insertion.



Figure 3: 3D T2 fatsat of the elbow. Acquired using the 15-channel knee coil. We have used the knee protocol without modification of acquisition parameters. Here the test was focused on the coil.

(Table 2, Fig. 4). 3D imaging for difficult patients becomes possible in MRI and is compatible with examination time constraints. It is the case for non-cooperative patients (e.g., pain symptoms, dementia) or unstable patients (requiring medical assistance: e.g. pediatric anesthesia ...) (Fig. 5).

The AutoAlign localizers started this philosophy of initiating an examination with a 3D protocol. Today, CAIPIRINHA SPACE enables 3D to do more than automating protocols by really imaging the brain. 2D protocols would be used in addition to bring ultra-high resolution and specific contrasts for specific pathologies.

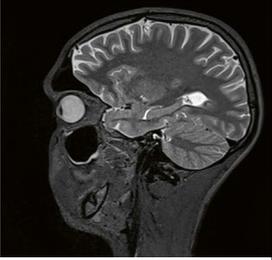
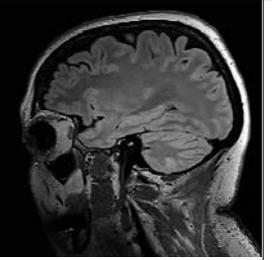
SPACE var T1	SPACE var T2	SPACE FLAIR	Slice thickness (mm)	Voxel size R (mm)	Total TA min:sec Without adjustment
MAGNETOM Aera 1.5T					
			1	0.5 x 0.5 x 1	07:56
TA 02:39	TA 02:50	TA 02:27			
MAGNETOM Prisma 3T			CAIPIRINHA p4: 2 x 2		
			0.9	0.5 x 0.5 x 0.9	07:20
TA 02:43	TA 02:02	TA 02:35			

Table 2: CAIPIRINHA SPACE really demonstrated its full potential in brain imaging. SPACE with variable (var) flip angle mode for T1 and T2.

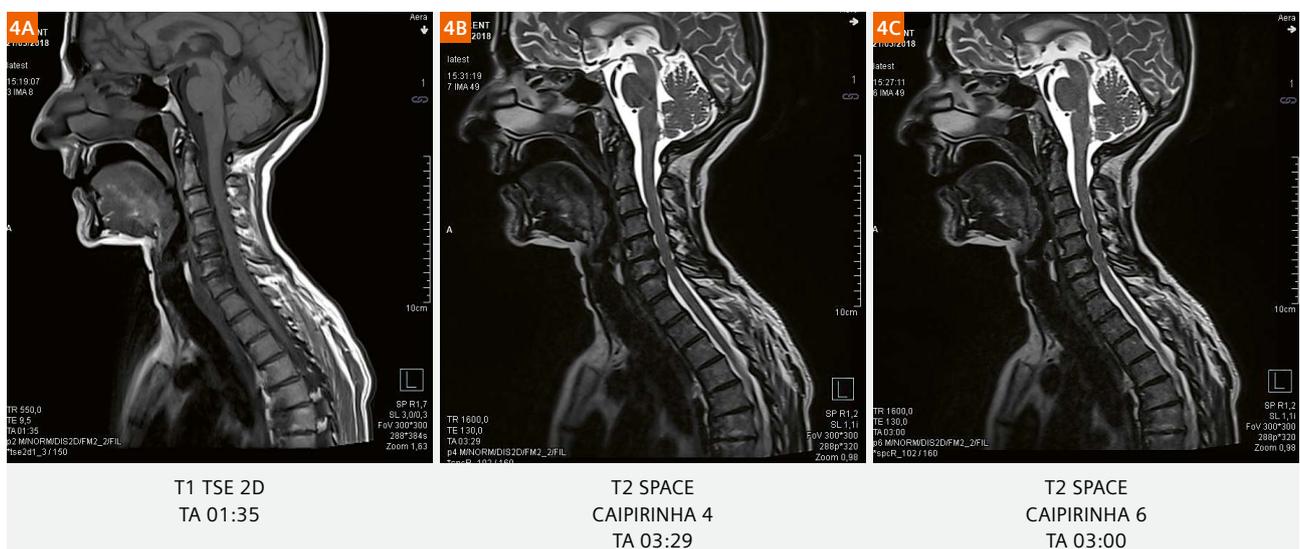


Figure 4: Time necessary for c-spine exploration in T1 TSE 2D 3 mm and T2 3D 1 mm can be less than 5 minutes. The Head/Neck 20-channel coil used here enables the use of CAIPIRINHA factor 6 (3 x 2) without reconstruction artifacts.

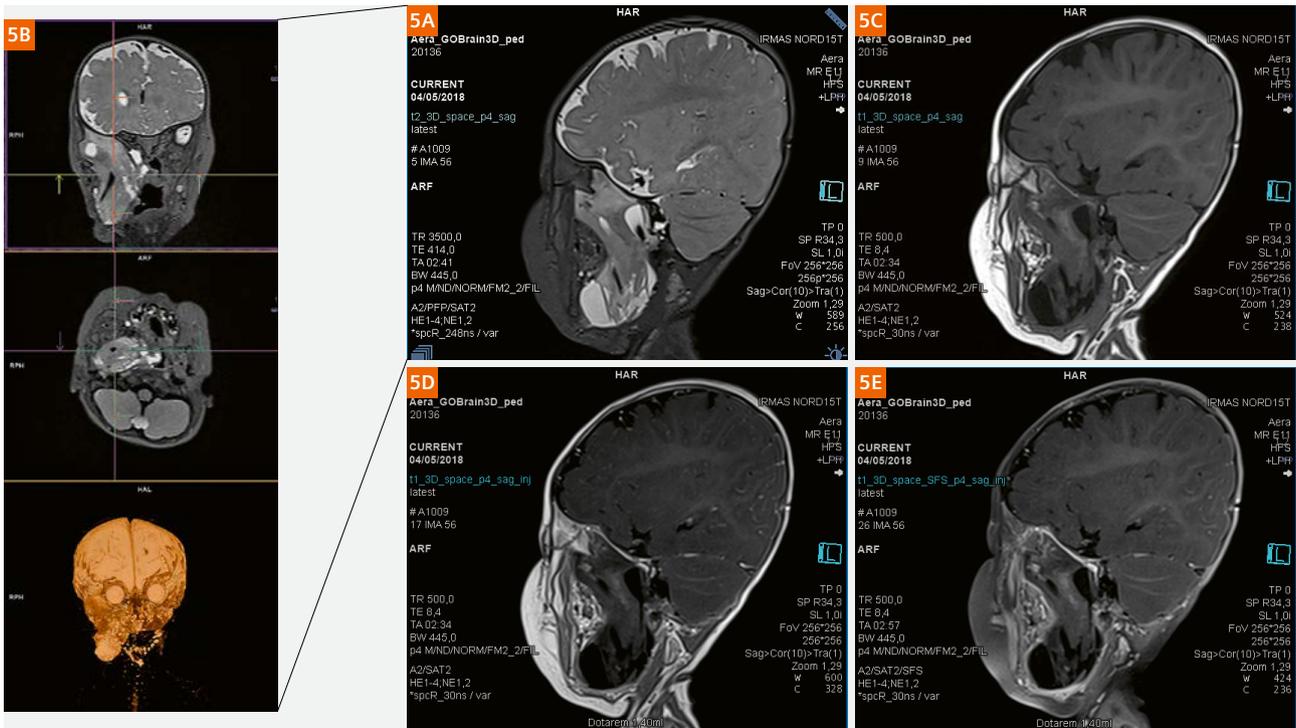


Figure 5: Examination of a 10-months-old child¹ under general anesthesia, in the context of ENT pathology follow-up. Target was to provide to radiologist all necessary information to evaluate patient response to therapy, in a very short acquisition time. In 10 minutes it was possible to run four 3D protocols with different contrasts (T2, T1, T1 with contrast enhancement, T1 fatsat with contrast enhancement), with MPR reconstructions (all consistent as done by the system through MPR Planning Dot AddIn). Anesthesia has been shorter, with easier recovery. A win/win examination for both patient and radiologist!

¹ Siemens Healthineers disclaimer does not represent the opinion of the author. MR scanning has not been established as safe for imaging fetuses and infants less than two years of age. The responsible physician must evaluate the benefits of the MR examination compared to those of other imaging procedures.

With the spine version of CAIPIRINHA SPACE, one usual argument of 3D spine imaging detractors disappears. Acquisition time and MPR reconstruction quality make it possible to outperform 2D protocols (Table 2).

Distributing CAIPIRINHA SPACE protocols to remote MR scanners

Our institution owns eight MR scanners (including five MAGNETOM Aera 1.5T). As a result, homogeneity within our fleet is a major issue. The more MRIs you have, the harder it is to reach this target. Using our MRIs in a coordinated way as well as being faster and more efficient in the optimization process of CAIPRINHA-SPACE for multiple body parts made it possible to examine more patients. To improve reactivity and for better ease-of-use, this process was achieved with the help of teamplay

Protocols for real-time distribution (Fig. 6). The distribution of the different versions, the exchange between different systems via the web platform of teamplay, in real time, realized a true gain in efficiency. The MR protocol hub option also gives access to the protocol/study files (.exar) published on MAGNETOM World at www.siemens.com/magnetom-world > Clinical Corner > Protocols.

Conclusion and outlook

CAIPIRINHA SPACE represents more than an acquisition technique; it really is a new acquisition philosophy where 3D finally takes the place it deserves in our imaging specialty. No body region is excluded (Fig. 7). CAIPIRINHA SPACE is currently accessible on all syngo MR E11C AP04 platforms, without an additional software license.

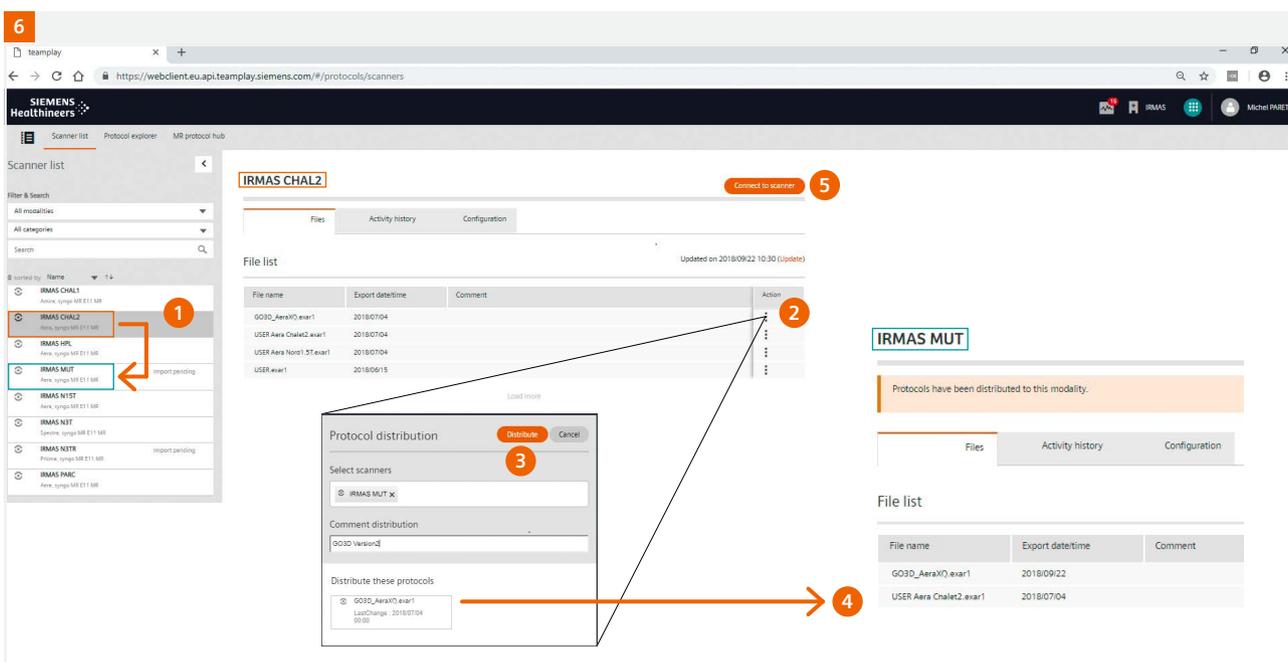


Figure 6: CAIPIRINHA SPACE protocol distribution (protocol name GO3D), using .exar file format, from one system to another. First the GO3D protocol is exported from the source system to be accessible in the teamplay Protocols interface. Protocol distribution is done from the teamplay interface, by first selecting the source system protocol, and then the destination system. Once distributed, the .exar file GO3D is accessible on the selected system. Two solutions are possible for the .exar file importation in the client user: either let the remote site import it through shared folder, or initiate a remote control session from the source system.

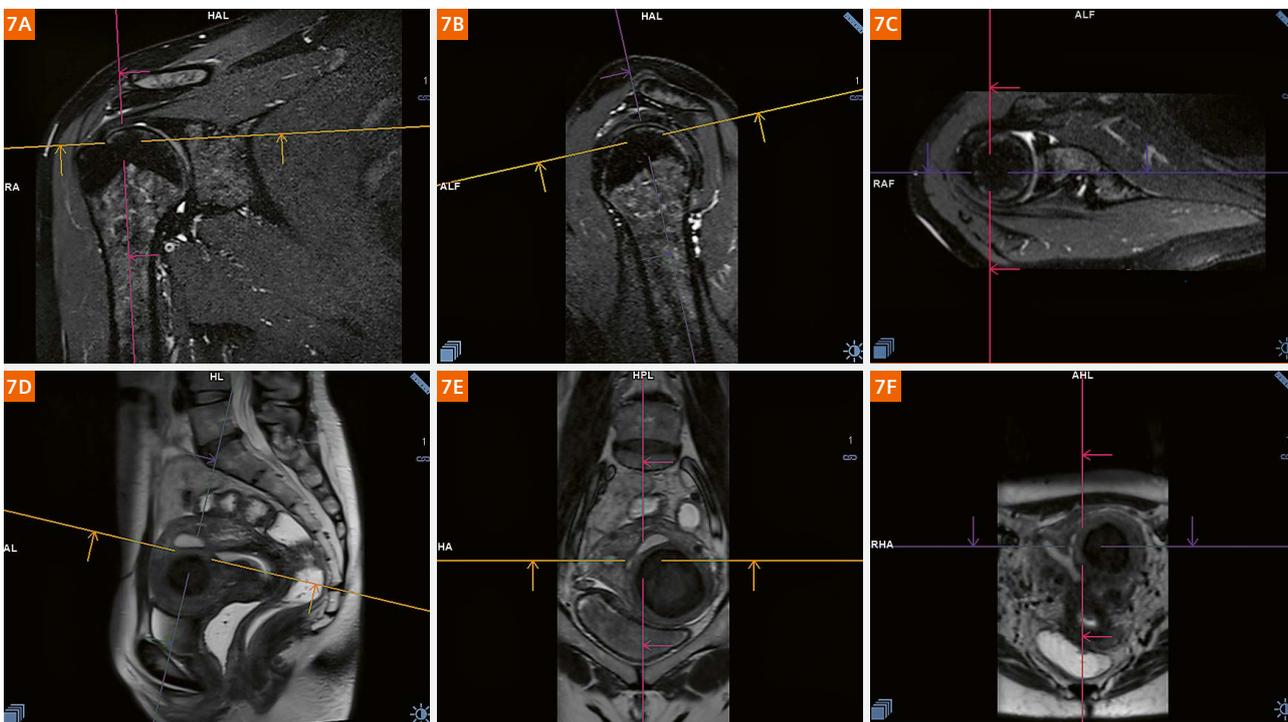


Figure 7: The CAIPIRINHA SPACE technique is robust enough to be used on more complex organs, sensitive to motion like shoulder (7A–C) or pelvis (7D–F).

Acknowledgements

Our recognition and gratitude goes to all the people participating in the development and optimization of the CAIPIRINHA SPACE technique multi-organs, operators, and radiologists in GIE IRMAS, our institution, marketing team, IT & Digital Care, Customer Service, and application specialists at Siemens Healthineers France, but also to Julien Gervais and Michaela Martin, Siemens Healthineers, with whom we collaborated intensively to digitalize our imaging processes.

Download CAIPIRINHA SPACE protocols for 1.5T MAGNETOM Aera and MAGNETOM Sola at

www.siemens.com/magnetom-world

> Clinical Corner > Protocols



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