

# How to Perform an Ankle MR Examination Without a Dedicated Coil: The Combined Head/Neck-Flex Coil Technique

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## Introduction

Magnetic resonance imaging (MRI) is often the modality of choice for diagnosis and treatment assessment in many musculoskeletal diseases of the ankle and foot [1]. Thanks to its high contrast and resolution, MRI can be used to demonstrate soft-tissue and bone abnormalities before they become apparent in other imaging modalities [2]. MRI examinations are especially valuable in soft-tissue disorders of the ligaments and tendons [3]. However, they are also excellent for the early detection of bone abnormalities, bone marrow edema, fractures, and contusions [4]. MRI is also a highly sensitive method for diagnosing and staging infections such as cellulitis, abscesses, and osteomyelitis [5].

Due to its anatomical structures, the ankle is one of the most complex joints to evaluate from a technical point of view. When performing MRI examinations of the ankle, it is important to take several aspects into account: First, patient positioning is of the utmost importance. The angle between foot and leg should be approximately 90°, in order to align bones and ligament structures [6]. In this way, the axial plane will be perpendicular to the tibia and parallel to the major axis of the astragalus, correctly cutting the talofibular ligaments. Second, appropriate protocols should be selected for each clinical question [7]. Sequence family, weighting, and orientation should be chosen based on the pathological condition (traumatic, degenerative, inflammatory, etc.). Third, given the size of the anatomical structures under investigation, spatial resolution is also an important factor. Spatial resolution and signal-to-noise ratio (SNR) are crucial for evaluating the anatomical and pathological conditions of the thin structures in the ankle.

The patient positioning for ankle imaging is usually supine, feet-first, with the ankle at the magnetic isocenter. The coil used might change depending on the hardware configuration and the software release and model. The optimal scenario would be to use a dedicated ankle/foot coil, which would enable the highest image quality in terms of SNR and spatial resolution, as well as a correct angle between the leg and the foot. However, if a dedicated coil



**1** Coil positioning with dedicated head cushion (red arrow) and dedicated flex coil pad (yellow arrow).

is unavailable or malfunctions, or if the size of the anatomy in question exceeds the coil capacity, it could be necessary to use alternative coils. Common alternatives include:

- **Knee Coil:** A dedicated knee coil provides very good image quality, but its shape and configuration mean it may be necessary to extend the joint. Extended positioning might not be appropriate for all ankle examinations.
- **Flex Coil:** These coils vary in terms of size and number of channels. The Flex Coil should be positioned as close as possible to the anatomy, with dedicated pads in between to avoid the risk of skin heating or patient discomfort. Positioning the ankle with only a Flex Coil could lead to motion artifacts because of the difficulties with patient immobilization.
- **Head/Neck Coil:** The size of this coil allows to image the whole ankle in any situation, with a homogeneous signal on a large field of view (FOV). On the other hand, the signal is usually lower than with other coil configurations.

This article proposes and demonstrates a novel method that combines a Head/Neck Coil and a Flex Coil. If a dedicated Ankle/Foot Coil is unavailable, it was hypothesized that combining these two coils could be an effective method of achieving the required image quality in a short scan time.



**2** Patient positioning with a thin cushion between the forefoot and coil (red arrow).

## Methods

All images were acquired on a 1.5T MAGNETOM Sempra (Siemens Healthcare, Erlangen, Germany) with syngo MR XA12 software, using a 16-channel Head/Neck receive Coil and a 4-channel Flex Coil.

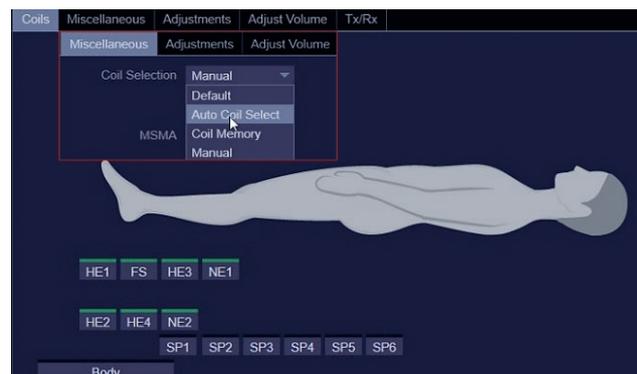
### Patient and coil positioning: the Head/Neck-Flex Coil technique

The Flex Coil is placed inside the Head/Neck Coil, with both coils plugged into the table. The dedicated head cushion and the dedicated flex coil pad are used, respectively, to drive the ankle at the isocenter in the anterior-to-posterior direction, and to avoid the risk of skin heating (Fig. 1).

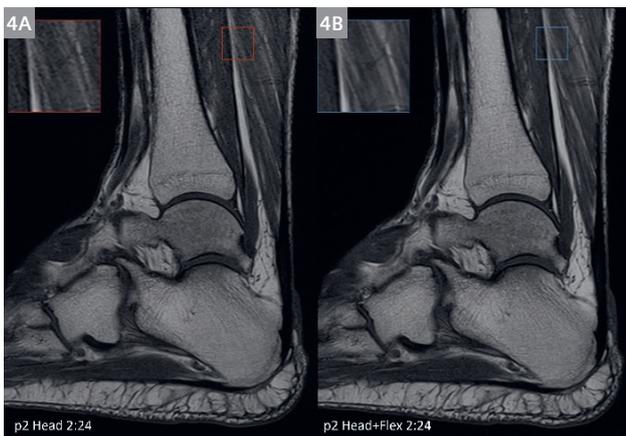
To prevent SNR loss, the anatomy should be placed inside the coils, with the Flex Coil positioned as closely as possible to the anatomy under examination. The forefoot comes out of the Head/Neck Coil and, to increase patient comfort, a thin cushion should be positioned between the foot and the head coil (Fig. 2). It is advisable to place a cushion under the knee to make the patient more comfortable.

The described setup increases patient comfort and keeps the anatomy more stable, reducing the risk of motion artifacts.

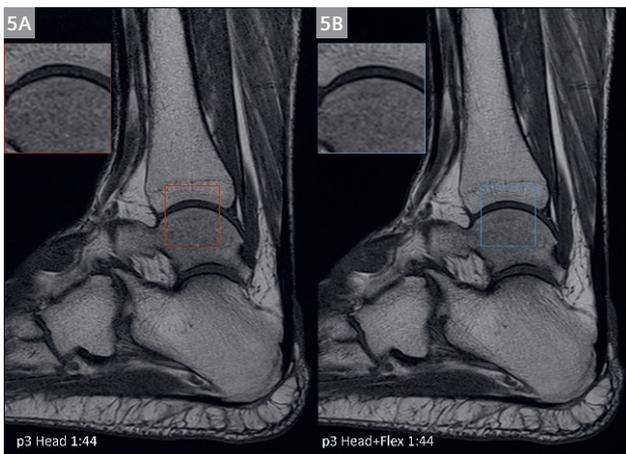
During protocol selection and scan, "Auto Coil Select" can be used to choose the coils on the user interface, as shown in Figure 3.



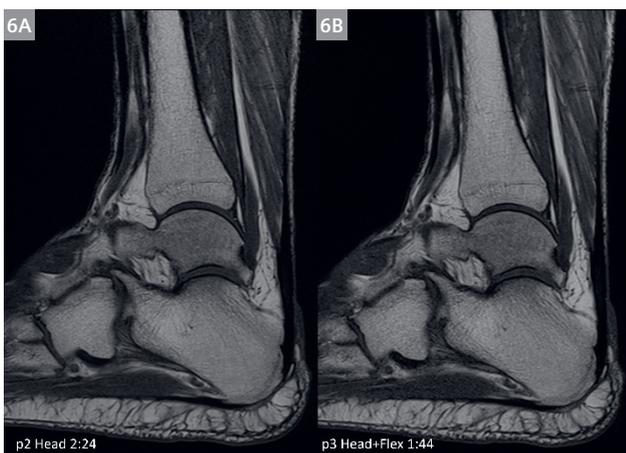
**3** The "Auto Coil Select" option turns on both the Head/Neck Coil (HE) and the Flex Coil (FS).



**4** Two TSE T1w images from the same patient: **(4A)** Head/Neck-only, **(4B)** Head/Neck-Flex Coil combination. Both images required a scan time of 2:24 min, but the coil combination improved the image quality.



**5** Two TSE T1w images from the same patient as in Figure 4. Head/Neck-only **(5A)**, Head/Neck-Flex Coil combination **(5B)**, using a parallel imaging acceleration factor of 3 (GRAPPA 3).



**6** TSE T1w images from the same patient. **(6A)**: GRAPPA 2 with Head/Neck Coil only; **(6B)**: GRAPPA 3 with Head/Neck-Flex Coil combination. The acquisition (in 6B) is faster but achieves the same image quality.

In order to evaluate the performance of the coil combination used, experiments were conducted using a TSE T1w sequence (TR 384 ms, TE 11 ms, Flip Angle 150°, SL 3 mm, FOV 180 mm) on a single asymptomatic subject (68-year-old female). Identical sequence parameters were acquired with the Head/Neck-Flex Coil combination, and with the Head/Neck coil only by de-selecting the Flex Coil channels. In a first experiment, images were compared with a GRAPPA factor of 2. In the other experiments, the effect of increasing the parallel imaging factor to 3 was investigated. The second experiment included the use of parallel imaging (GRAPPA = 3) on both coil configurations to assess how much image quality was gained with the coil combination. A third experiment compared a GRAPPA factor of 3 in the coil combination technique with a GRAPPA factor of 2 in the Head/Neck-only configuration, to assess whether the coil combination can be used to accelerate the scan time while preserving the image quality.

## Results

Figure 4 shows two TSE T1w images from the same patient, acquired with the Head/Neck Coil only (4A) and with the Head/Neck-Flex Coil combination (4B). The image quality is sufficient in both images. However, with the Head/Neck-Flex Coil combination (4B), the SNR is higher across the entire field of view. This is particularly evident on the distal leg portion. The coil combination increases the quality of the images yet maintaining the same acquisition time.

Figure 5 shows two TSE T1w images from the same patient, acquired with the Head/Neck Coil only (5A) and the Head/Neck-Flex Coil combination (5B), using an acceleration factor of 3 (GRAPPA 3). The scan time is the same, but some noise is evident in image (5A). The coil combination allows to increase the acceleration factor, which reduces the scan time and keeps the SNR at a sufficient level.

Figure 6 shows a direct comparison between the same TSE T1w of the previous patient, acquired with Head/Neck only and GRAPPA 2 (6A) and with Head/Neck-Flex Coil combination and GRAPPA 3 (6B). The image quality is similar, but the scan time has been reduced from 2:24 to 1:44 min. In addition, the SNR of the distal part of the leg appears improved in the combined coil approach.

It is possible to apply the same approach to other sequences in the ankle protocol, reducing the total scan time. The proposed fast protocol, based on the coil combination technique, is shown in Table 1.

## Discussion

Imaging the ankle without a dedicated coil can be challenging. This article shows how to combine a Head/Neck Coil and a Flex Coil in a technique that can be used when

Sequence	Voxel size (Acquisition)	Voxel size (Reconstruction)	Slices n° × thickness	Scan time
TSE T1 Sag.	0.53 × 0.42 mm	0.2 × 0.2 mm	20 × 3 mm	2:15 min
TSE STIR T2 Sag.	0.74 × 0.63 mm	0.3 × 0.3 mm	20 × 3 mm	2:46 min
TSE T2 Tra.	0.69 × 0.55 mm	0.3 × 0.3 mm	27 × 3 mm	1:43 min
TSE T2 FatSat Tra.	0.69 × 0.55 mm	0.3 × 0.3 mm	27 × 3 mm	2:07 min
TSE Dixon PD Cor.	0.66 × 0.66 mm	0.3 × 0.3 mm	23 × 3 mm	2:52 min

**Table 1:** Fast protocol based on the coil combination technique. All the sequences have GRAPPA enabled at an acceleration factor of 3. Neither Compressed Sensing (CS) nor Simultaneous Multi-Slice (SMS) were used.

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a dedicated coil is unavailable. The results show that this kind of coil combination is an effective way of improving the image quality with a similar scan time to a Head/Neck Coil only. The article also assesses the effect of parallel imaging on accelerating the acquisition when using the proposed coil combination. More specifically, the Head/Neck-Flex Coil combination is effective at reducing the scan time while maintaining the same quality level. Also, it allows the parallel imaging acceleration factor to be increased, which reduces the scan time and maintains SNR at a sufficient level.

In conclusion, combining Head/Neck and Flex coils for ankle MRI examinations is an effective method for obtaining excellent image quality and reducing the impact of motion artifacts in the absence of a dedicated Ankle/Foot Coil. The coil combination increases the SNR, which can either speed up the scan while maintaining a similar quality, or obtain a superior quality while maintaining a similar scan time. The patient positioning, coil positioning, and dedicated support keep patients comfortable and safe during examinations that use this special configuration.

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