Knee magnetic resonance imaging: Comparative study between spin echo sequence and conventional thick-slice imaging

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Abstract: The development of new MRI technologies has favored the use of sequences that significantly improve the spatial resolution of this imaging method, thus yielding thin-section images that allow volumetric analysis. We present our experience at Clínica Vespucio, Santiago, Chile, related to a routine knee MRI protocol performed on 45 patients who underwent conventional proton density-weighted fat-saturated sequence (PDwFS) 3-mm section thickness along with proton density-weighted fat-saturated sequence with thin-section (1.2 mm). In most cases, the thin-section PDwFS allows a better anatomical characterization of lesions, particularly meniscal and condral injuries, with minimal increase in image acquisition time.

Keywords: Thin-section, Knee, MRI.

Resumen: El desarrollo de nuevas tecnologías en resonancia magnética ha favorecido el uso de secuencias que mejoran significativamente la resolución espacial del método, obteniendo imágenes de cortes finos que permiten análisis volumétrico. Se presenta la experiencia en Clínica Vespucio en un protocolo rutinario de estudio de rodilla, con evaluación de 45 pacientes consecutivos a los que se les realizó secuencia tradicional de densidad protónica con saturación grasa (DPFS) de corte grueso (3 mm) y secuencia DPFS volumétrica de corte fino (1,2 mm). En la mayoría de los casos es posible realizar mejor caracterización anatómica de las lesiones, principalmente meniscales y condrales, con un mínimo aumento en el tiempo de estudio.

Palabras clave: Corte fino, Resonancia magnética, Rodilla.

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Introduction

Development of new magnetic resonance imaging (MRI) technologies, mainly those with higher speed gradients and multi-channel equipments, has favored the use of sequences that significantly improve spatial resolution of acquisitions, thus obtaining thin-section images that allow volumetric analysis. Most of them correspond to gradient echo sequences; however, its use has not been generalized in osteoarticular imaging due to susceptibility to artifacts and poor tissue contrast, being highly useful in special sequences for assessment of cartilage (e.g., WATS 3D, Philips Medical Systems). Commonly, thick-section spin-echo sequences (SE) are mainly used.

We present our experience (Clínica Vespucio, Santiago, Chile) in the utilization of thin-section, volumetric SE proton density-weighted fat-saturated (PDwFS) sequences in routine knee study protocol.
Our aim is to demonstrate that improvement in injury detection can be achieved by using above sequence, in comparison with traditional thick-slice PDwFS sequence.

Material and methods

Studies were performed in a 16-channel resonator (Achieva 1,5 T from Philips Medical Systems), and an 8-channel dedicated knee antenna (Philips Medical Systems) was used.

Fourty-three patients underwent sagittal PD-wFS sequences (3-mm slice thickness, 0.3 mm interslice gap, 28 slices, TR 3244 ms, TE 30 ms, turbo factor of 25, matrix of 512x512, RFOV 160 FH x 160 AP x 95 RL, without SENSE factor, with a duration of approximately 145 seconds, along with 1.2-mm slice thickness, volumetric sagittal PDwFS sequence, interval of 0.6 mm (50% overlap), 160 slices, TR 800 ms and TE 35 ms, turbo factor of 45, matrix of 512x512, RFOV FH 160 x 160 AP x 95 RL, with factor SENSE 1.7 and a duration of approximately 200 seconds.

Identification of sequences was removed and results were analyzed by two physicians with over 6 years experience as musculoskeletal radiologists.

A comparative descriptive study was conducted, evaluating both sequences for each patient, defining the findings, and particularly specifying if there was actual benefit with thin-section volumetric sequence versus thick-slice conventional sequence.

Results

Forty-four examinations were performed on 43 patients (both knees were evaluated in one case), 21 women and 22 men, aged between 9 and 56 years (mean age of 33 years). Right knee was studied in 25 cases, while left knee was analyzed in 19 examinations.

Out of the 44 exams, 10 were normal on both thick- and thin-section fat-saturated proton density-weighted sequences. In 17 cases, the use of thin-section PDwfs images resulted in actual contribution to the diagnosis; in nine of them, this imaging technique allowed visualization of meniscal tears not seen on thick-section sequences, while in 18 cases, findings remained unchanged, on both thick- and thin-section PDwfs sequences, albeit according to observers a better definition was achieved (Figures 1, 2).

There was bone edema in 19 cases, condition that was less evidently recognized on the thin-slice sequence despite being clearly identified in all cases (Figure 3).

Regarding chondral, tendon or ligament injuries, no significant difference was observed in their detection; nevertheless, their definition was better on thin-section imaging.

Figure 1. Radial tear of the meniscus body, difficult to visualize on thick-slice images, was better defined on thin-slice views and clearly displayed on axial reconstruction. a) Thick-slice sagittal PDwFS sequence. b) Thin-slice sagittal PDwFS imaging c) Axial image reconstructed from FSPDw thin-section volumetric acquisition.
In MR imaging, 3D sequences with isotropic resolution are usually based on gradients, particularly on steady state-free precession sequences (1-5). Results of two studies (3,5), have shown that these sequences may be used to provide rapid and detailed assessment of the knee joint. Some studies (5) have described potential limitations of T1-T2 weighted tissue contrast in these sequences; thus, despite their spatial resolution, sensitivity and specificity may eventually be similar to conventional non-isotropic thick-slice SE acquisitions.

Figure 2. Horizontal tear of medial meniscal posterior horn not displayed on thick-slice imaging but clearly shown on thin-section and coronal reconstruction images. a) Thick-slice sagittal PDwFS sequence, b) Thin-slice sagittal PDwFS sequence, c) Coronal image reconstructed from fat-saturated proton density-weighted thin-section volumetric study.

Figure 3. Fibular neck fracture and bone bruise in lateral tibial plateau: bone edema is displayed more clearly and intensely on thick-section sequence, while it is less intensely recognized on thin-slice acquisition, though still clearly visible. Note fibular neck fracture, with features more clearly recognized on thin-section image. a) Thick-slice sagittal PDwFS sequence, b) Thin-slice sagittal PDwFS sequence.

Discussion

In MR imaging, 3D sequences with isotropic resolution are usually based on gradients, particularly on steady state-free precession sequences (1-5). Results of two studies (3,5), have shown that these sequences may be used to provide rapid and detailed assessment of the knee joint. Some studies (5) have described potential limitations of T1-T2 weighted tissue contrast in these sequences; thus, despite their spatial resolution, sensitivity and specificity may eventually be similar to conventional non-isotropic thick-slice SE acquisitions.
The 3D-FSE-Cube sequence with isotropic resolution is a promising new MR imaging technique for replacing 2D sequences currently used in clinical practice.

Three-dimensional FSE acquisitions allow us to obtain proton density-weighted images, the most commonly used sequence in musculoskeletal MR imaging\(^7,8-16\). Major advantage of this sequence is its spatial resolution, which enables multiplanar reconstructions in arbitrary orientations which, in turn, favors image interpretation (Figure 4).

In our study, 3D PDwFS sequence provided better information in a significant number of cases; in fact, it is even plausible to state that all the information contained in a comprehensive multisequence study of about 25 minutes could be virtually included on a single 3D PDwFS acquisition. The greatest benefit of 3D PDwFS sequence is seen in the evaluation of menisci, given its capability to detect new or more extended lesions than those visualized on thick-slice PDwFS scanning (Figures 5, 6). This had been previously demonstrated by Yoon et al.,\(^6\), who demonstrated its capability to detect meniscal lesions, when correlated with arthroscopic results.

**Figure 4.** Multiplanar reconstructions from original cuts: best spatial resolution of thin-slices, with feasibility of isotropic reconstructions is clearly shown. a) Sagittal reconstructions from thick-section PDwFS images, b) Sagittal reconstructions from thin-section PDwFS views.

**Figure 5.** Peripheral horizontal tear of the medial meniscus body: thick-section intrasubstance abnormally increased signal intensity image; on thin-slice sequence its linear nature is clearly defined, and coronal reconstruction clearly identifies tear reaching capsular edge of the meniscus. a) Thick-slice sagittal PDwFS sequence, b) Thin-slice sagittal PDwFS sequence, c) Coronal image reconstructed from thin-slice PDwFS volumetric sequence.
Three-dimensional PDwFS sequence allows excellent visualization of the articular cartilage, particularly due to a reduced partial-volume artifact, theoretically allowing detection of smaller cartilage lesions. As for our study, no significant difference in the detection of chondral pathology was observed; however, improved detailed information was provided (Figure 7).

Figure 6. Horizontal tear of medial meniscal posterior horn: on thick-slice sequence, a linear image suspicious of tear can be seen; thin-slice sequence clearly identifies meniscal tear with greater peripheral involvement. a) Thick-slice sagittal PDwFS sequence, b) Thin-slice sagittal PDwFS sequence.

Figure 7. Visualization of chondral lesions: apparent full-thickness patellar chondral injury is visualized on thick-slice image, whose contour is best defined on thin-section sequence and appears clearly identified on axial reconstruction. a) Thick-slice sagittal PDwFS image, b) Thin-slice sagittal PDwFS image, c) Axial image reconstructed from thin-section PDwFS volume sequence.

As for evaluation of tendons and ligaments, a relevant difference was not found. This finding is consistent with what has been reported in the literature,
concerning available evidence about similar specificity and sensitivity of this sequence compared to the routine musculoskeletal MRI protocol\textsuperscript{[6]}. Interestingly, due to its multiplanar capability, it is possible to perform reconstructions in oblique planes, thus following the path of different structures to be evaluated\textsuperscript{[10,16-18]} (Figure 8).

![Figure 8](image)

**Figure 8.** The anterior cruciate ligament appears as continuous but with partially defined contours on thick-slice image; thin-section sequence clearly shows conservation of continuous fibrillar pattern. a) Thick-slice sagittal PDwFS image, b) Thin-slice sagittal PDwFS image.

In the case of edema, its detection is similar in both types of sequences, even though on 3D PDwFS sequence edema is depicted with lower signal intensity. This is determined by short TR which sacrifices T2 load by maintaining an adequate number of cuts as well as time sequence, as a part of the test conception; in order to shorten sequence acquisition time without reducing the number of cuts, the “T2 load” of examination is sacrificed, which significantly shortens TR.

Regarding time consumed by both sequences, duration of thin-section 3D sequence is about 1 minute longer than the traditional thick-section acquisition; this seems acceptable given the benefits obtained and may even translate into resource saving provided that similar thick-slice sequences obtained in other planes may be eliminated.

This study exhibits some limitations attributable to the small number of patients studied, thus implying lack of full statistical analysis, which explains the descriptive nature of the current study. Ideally, studies with larger numbers of patients should have to be performed, comparing the complete routine protocol versus this unique sequence, and including arthroscopic correlation as the gold standard.

**Conclusion**

Routine performance of thin-section 3D PDwFS volume sequence of the knee allows appropriate characterization of lesions as well as diagnosis of smaller alterations, with minimal sacrifice in sequence acquisition time. Inclusion of this sequence in the routine knee MRI protocol, whenever equipment allows it, seems worth considering.

**References**

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