

DEVELOPMENT OF AN OPEN SOURCE TOOL TO AID IN THE EVALUATION OF KNEE CARTILAGE INJURIES

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Abstract— Background: When the cartilage is preserved, the collagen hinders the water mobility, resulting in a short T2 value. However, when this structure is weakened, the flow of water through the cartilage is intense, thus increasing the T2 values. In this way, with Magnetic Resonance Imaging (MRI), T2 maps indirectly present the cartilage content analysis. T2 mapping is commonly used in the evaluation, progression and diagnosis of cartilaginous regions of the knee once it uses a suitable protocol for MRI acquisition and specific software for the post-processing step. Purpose: To develop a tool (open source free software) for the study of T2 relaxometry. **Methods:** Using a 1.5 T MRI, we obtained MRI from seven patients and developed a program in MATLAB to generate T2 maps.

Results: We developed a software program and named it Mapas T2, (Figure 1). The tools and functionalities of the proposed application were based on of Usability principles (International Organization for Standardization (ISO), and the clinical needs of radiologists and academics.

We created a tool that allows the user to contour the anatomical areas in free format, thus obtaining the T2 value of the one or more region of interest (ROI) simultaneously (Figure 2). This tool proves important if one considers that the irregular structures of the knee suggest the need to map the anatomical regions of the cartilage in segmented areas.

We implemented the T2 map generator feature with all sequence images (batch processing mode). This function avoids the need to partition the exam, showing only echoes in an orderly manner in the regions of interest. For example, a protocol with 14 echoes may result in 210 images to cover the whole anatomy of the knee, and with the developed tool it is possible to order the images at every 15 echoes and obtain T2 maps of the entire anatomy.

With the tool, one can visualize the decay curve of the region of interest with the value of the Mean Square Error (MSE). This information allows the user to deliberate on the fitting curve and whether the value of the error is within the degree of reliability adopted in the study.

In the post-processing and T2 mapping step, the script runs automatically and disregards the first echo of the sequence. Then, in a sequence with 10 echoes, only 9 will be used for the calculations. This particular function was implemented in order to minimize intrinsic errors in multi-echo imaging sequence and in T2 estimation since

some physical aspects in the first echo are not considered.

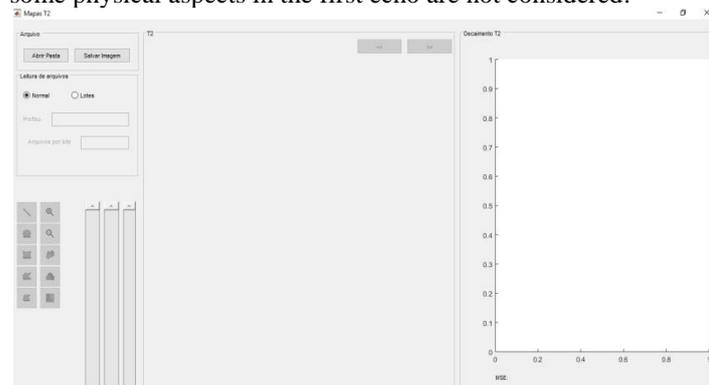


Fig. 1. Interface of the Mapas T2 application. Once the files containing the images are selected, the processed T2 map is displayed in the viewer and, after selection of an ROI, the decay curve is displayed.

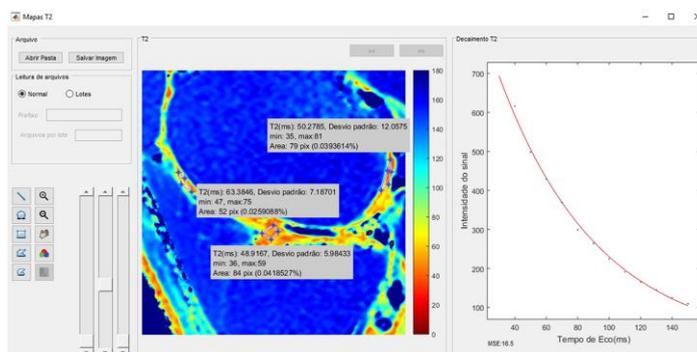


Fig. 2. Simultaneous visualization of three ROIs on a single T2 map

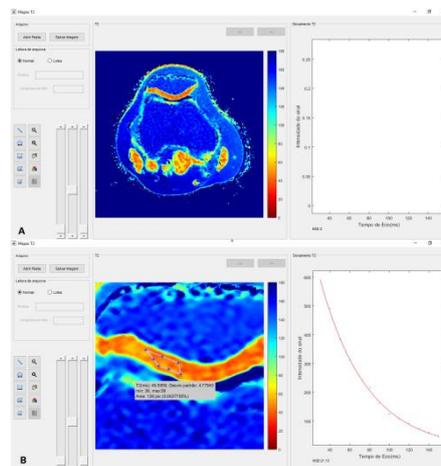


Fig. 3. A) T2 map obtained with 14 echoes. B) The zoom function was used to aid in the visualization and to obtain an ROI in the cartilage.

Immediately, the software provides the T2 value, the decay graph and the MSE value. The user can choose the batch processing mode, so the application will simultaneously provide 20 T2 maps, as shown in Figure 4.

Initially, we performed a pilot test from which we obtained a series containing 280 MRI images in the sagittal plane of the knee of a healthy volunteer (male, 36 years old). In a folder, we separated 14 images of the medial portion and selected the normal processing mode to read the files, resulting in a single T2 map (Figure 3).

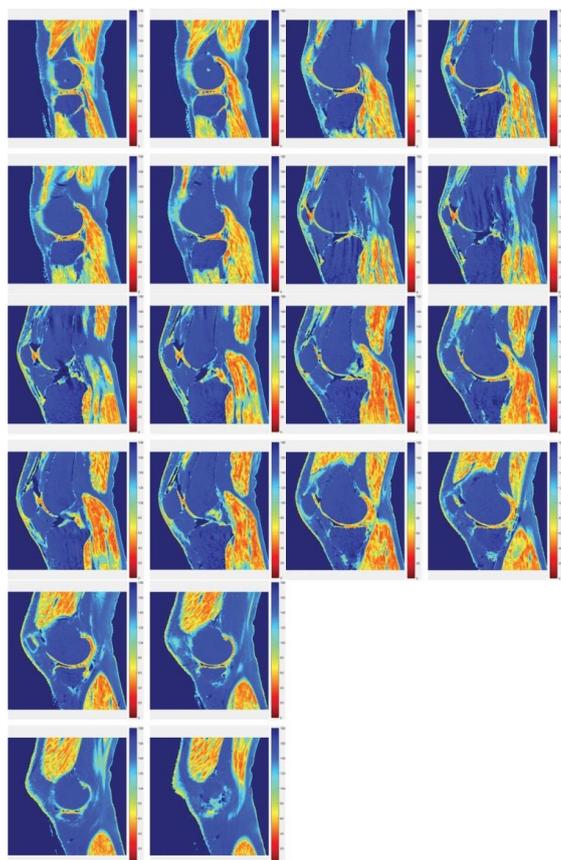


Fig. 4. Simultaneous post-processing procedure of 280 MR images.

We obtained the T2 maps in the clinical routine by MRI of a group of seven patients ($N = 7$), all of them referred to magnetic resonance examination of the right knee. In other words, there were no calls for patients or volunteers, and the study was approved by the Ethics and Research Committee of UNIFESP (CAAE:16837213.1.0000.5505). In the comparison with the three free programs, no significant difference was found between the values of the T2 maps.

Conclusion: The software developed, now made available to academic and professional environments allows generating T2 maps of cartilaginous structures of the knee in an agile way and with usability features.

The Mapas T2 application is an open source code and it is freely available (<http://mapast2.site123.me>) under the General Public License (GNU) for non-commercial use and open source development.

Keywords — Cartilage. Relaxometry. T2 maps. MATLAB. Knee. Magnetic Resonance Imaging.