T1ρ weighted imaging in middle ear cholesteatoma

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Target audience: Researchers and clinicians interested in T1ρ imaging.

Introduction: T1ρ imaging is an MR imaging method that allows for quantification of biological tissues (such as protein) with few rapid motions and a large amount of slow motions that are not available from T1 and T2 measurement.[1] Diffusion-weighted imaging (DWI) is widely used and it provides useful information in detecting cholesteatoma. However, it is difficult to distinguish cholesteatoma from abscess formation. In addition, some cholesterol granuloma show hyperintensity on DWI. In such cases, new approaches are required to solve the problem. T1ρ imaging is one of a potential source that may provide information about the macromolecular properties of tissues. [1, 2] This unique imaging method has been used to evaluate articular cartilage[3] and Alzheimer's disease,[4] tumor response to treatment,[5] and new clinical applications are being discovered. In this study, we assessed the feasibility of T1ρ imaging in diagnosing middle ear cholesteatoma.

Materials and Methods:

Subjects: Ten patients including seven with cholesteatoma (M/F= 1/6, age 23 to 73 years, mean 48.4 years) and three with non-cholesteatoma (M/F= 2/1, age 24 to 66 years, mean 49.7 years) were studied. The non-cholesteatoma group consisted of abscess formation, granuloma, and cholesterol granuloma. Both cholesteatoma and non-cholesteatoma were surgically confirmed by otorhinolaryngologists. Each patient underwent preoperative MRI on the day before surgery. *MRI*: All subjects underwent MRI studies using a 3.0 T clinical unit (Achieva TX Philips Healthcare) with an 8-channel SENSE head coil. For each subject, the T1ρ weighted images were performed using a 3D T1 weighted turbo field echo sequence with the phase encode along the R-L direction. The imaging parameters were as follows: TR/TE = 5.6ms/2.7ms, FOV = 230×218mm, matrix = 420×256, slice thickness = 3mm, flip angle = 35°, TFE factor = 256, spin lock frequency = 500Hz, spin lock times (TSLs) = 1/20/40/80/120ms, number of slice = 12, NSA = 1, imaging time = 1min27s for each spin lock time. In addition, transverse T2-weighted TSE images (slice thickness/gap = 2 mm/1 mm) and multi-shot echo-planar imaging (MS-EP) DWI (b factor = 800 s/mm^2, slice thickness/gap = 2 mm/1 mm) were also obtained. *Image analysis*: The T1ρ imaging data corresponding to 5-different TSLs were fitted voxel-wise to mono-exponential decay algorithm. The signal intensity S in T1ρ weighted image was represented by the following formula: $S = S_0 \times \exp(-TSL/T_{1\rho})$, where S_0 is the signal intensities when the TSL is zero. Quantitative T1ρ maps were generated using Philips Research Integrated Development Environment (PRIDE) software written in Interactive Data Language (IDL 6.3, ITT Inc., Boulder, CO, USA). Region-of-interests were placed to include the whole lesion for each case.

Results: The T1ρ values in cholesteatoma were 103.3 ± 23.6ms (mean value ± SD). The T1ρ values of abscess formation, granuloma, and cholesterol granuloma (non-cholesteatoma) were 61.1, 64.1, and 174.0ms, respectively, which were clearly different from those obtained in cholesteatoma (Fig. 1). The typical cases are illustrated in Fig.2 and Fig.3.

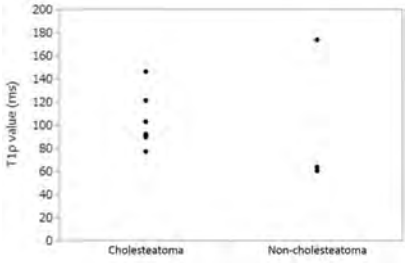

Fig.1: Plots of the average T1ρ values for cholesteatoma and non-cholesteatoma groups. The average T1ρ values in cholesteatoma ranged 103.3 ± 23.6ms, which were clearly different from those obtained in non-cholesteatoma.

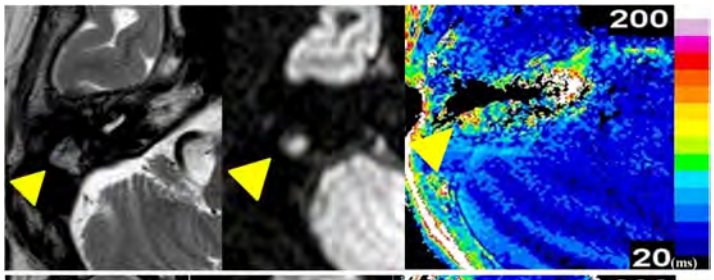

Fig.2: T2WI (left), MS-EP DWI (middle), and corresponding quantitative T1ρ map (right) of a 73-year-old female with recurrent cholesteatoma in the right middle ear. The lesion demonstrates hyperintensity on MS-EP DWI. The T1ρ value was 103.1ms in the lesion.

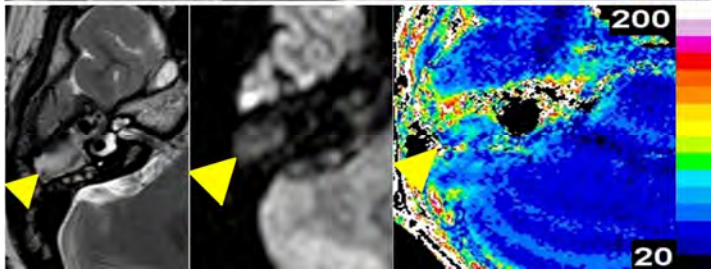

Fig.3: T2WI (left), MS-EP DWI (middle), and corresponding quantitative T1ρ map (right) of a 24-year-old female with abscess formation in the right middle ear. The lesion demonstrates moderate intensity on MS-EP DWI. The T1ρ value was 64.1ms in the lesion, which is clearly different from those in cholesteatoma.

Discussion: We demonstrated the feasibility of T1ρ imaging in diagnosing middle ear cholesteatoma from other middle ear diseases. To our knowledge, this is the first report of T1ρ imaging of assessing middle ear diseases. Cholesteatoma is composed of keratinizing squamous epithelium, and previous study revealed that many proteins were identified in cholesteatoma.[6] Although the precise mechanism of pathogenesis is not fully elucidate, our results will help us for a better understanding of cholesteatoma pathology.

Conclusion: Our results indicate that T1ρ imaging is a promising tool for the diagnosis of cholesteatoma.

References: 1. Redfield AG. Phys Rev. (1955) **2.** Charagundla SR. Appl Radiol. (2003) **3.** Regatte RR, et al. Radiology. (2003) **4.** Borthakur A, et al. Neuroimage. (2008) **5.** Duvvuri U, et al. Cancer Res. (2001) **6.** Britze A., et al. PLOS one. (2014)