Age-dependent gagCEST effect in human lumbar intervertebral discs

Frithjof Wickrath[1], Anja Müller-Lutz[1], Christoph Schleich[1], Benjamin Schmitt[2], Tom Cronenberg[1], Rotem Shlomo Lanzman[1], Falk Miese[1], and Hans-Jörg Wittsack[1]

[1]Department of Diagnostic and Interventional Radiology, University Dusseldorf, Medical Faculty, D-40225 Dusseldorf, NRW, Germany, [2]Healthcare Sector, Siemens Ltd. Australia, Australia

Target audience: Physicist and physicians interested in CEST imaging and musculoskeletal imaging.

Purpose: To evaluate, if the chemical exchange saturation transfer effect of glycosaminoglycans (gagCEST) representing the amount of glycosaminoglycans alters with age in the cartilage of human lumbar intervertebral discs.

Methods: T2-weighted and gagCEST imaging (prototype sequence) was performed on a 3T (Magnetom Trio, A Tim System, Siemens Healthcare, Erlangen, Germany) using a standard clinical spine matrix coil for signal reception. 70 volunteers from 21 to 69 years were enrolled and categorized into five age groups in steps of 10 years. The study was approved by the local ethics committee and written informed consent was obtained from all volunteers. For correction of magnetic field inhomogeneity water saturation shift referencing (WASSR) (1) with B1-amplitude of 0.3 µT and pulse duration of 100 ms was used. Further WASSR sequence parameters were: TE/TR = 3.01 ms / 590 ms, in-plane resolution = 1.6 x 1.6 mm^2, slice thickness = 5 mm, flip angle = 12°, field of view = 300 x 300 mm^2, number of signal averages = 6, sequence duration = 7:26 min:sec. The gagCEST preparation module consisted of 6 Gaussian-shaped RF pulses with a pulse and interpulse duration of 100 ms and a B1 amplitude of 1.5 µT averaged over time. Further gagCEST sequence parameters were: TE/TR = 3.01 ms / 1590 ms, in-plane resolution = 1.6 x 1.6 mm^2, slice thickness = 5 mm, flip angle = 12°, field of view = 300 x 300 mm^2, number of signal averages = 6, sequence duration = 12:24 min:sec. GagCEST analysis based on the magnetization transfer asymmetry ratio MTR_{asym} was performed in two regions: nucleus pulposus (NP) and annulus fibrosus (AF). Mean MTR_{asym} values of each age group were compared (ANOVA). P-values < 0.05 were considered significant.

Results: MTR_{asym} decreases significantly from 3.09 % ± 1.12 % for 20-29 years old volunteers to -0.24 % ± 1.36 % for 50-59 years old volunteers in NP (p-value < 0.001) and from 1.51 % ± 1.13 % to -0.85 % ± 1.34 % in AF (figure 1). Figure 2 shows MTR_{asym} decrease with aging in healthy lumbar intervertebral discs of three individual volunteers.

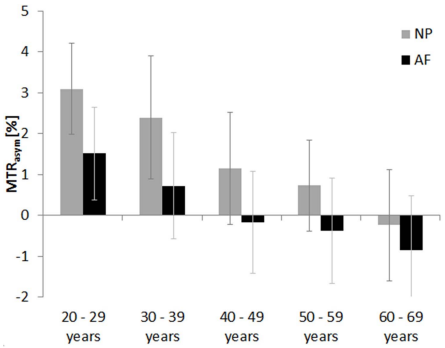

Figure 1. MTR_{asym} evaluated for each age group in nucleus pulposus (NP) and annulus fibrosus (AF)

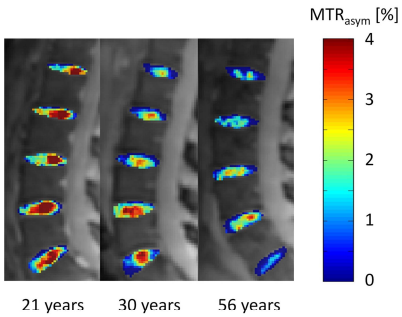

Figure 2. Decrease of gagCEST effect with aging in healthy lumbar intervertebral discs.

Discussion: GagCEST results strengthen the idea of a loss of glycosaminoglycan content with age. Hence, we report the importance considering aging for glycosaminoglycan content assessment with the gagCEST method. The gagCEST effect is considered to be related to degeneration of cartilage (2,3). Therefore, the decreased glycosaminoglycan content may be related to a degeneration process. The glycosaminoglycan content was approximately zero for groups 4 and 5. The slightly negative MTR_{asym} values may be explained by noise and artefacts.

Conclusion: We revealed a decreased gagCEST effect and therefore decreased amount of glycosaminoglycans with aging. Hence, age-matched gagCEST analysis is necessary in future.

References:

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