Introduction:
dGEMRIC is used for investigating pre-radiographic stages of osteoarthritis (OA) in the hip and knee. After given time to penetrate the cartilage, the ionic contrast agent Gd-DTPA²⁻ distributes in a negative relationship to the tissue fixed charged density (FCD), mainly comprised by the glucosaminoglycans (GAGs). T1 in the presence of Gd-DTPA²⁻ may therefore be used as a surrogate marker for tissue integrity. Recent studies have indicated that the menisci are involved in early stage of degenerative joint disease, and that the menisci play an important role for knee stability. With this perspective, new methods to study the integrity of the menisci are needed. This study describes the temporal dynamics of contrast distribution in both meniscus and femoral cartilage over time using two different doses of Gd-DTPA²⁻.

Methods:
12 asymptomatic volunteers, (5 male) age 23-28 years (mean 25) were examined twice (5-6 months between the examinations) after an intravenous injection of Gd-DTPA²⁻ at double and triple doses (0.2 and 0.3 mmol/kg body weight), respectively. A Siemens Sonata 1.5 T scanner with a CP Extremity coil was used. An in-house developed 3-dimensional Look-Locker sequence (FOV 160x160 mm, Matrix 256x256 pixels, 30 slices, 3 mm slice thickness, TR 2500 ms, FA 6°, 10 TIs) was used to acquire 3-dimensional T1 maps covering both the meniscus and the cartilage. The Look-Locker T1 data was evaluated using the pre-calculated flip angle correction method. The posterior horn of the meniscus and the weight bearing femoral cartilage in both the lateral and medial compartment were analyzed. Imaging with corresponding T1 analysis was performed before and four times (60; 90; 120; 180 min) after the intravenous injection. In order to establish the concentration of Gd-DTPA²⁻ in the tissues, AR1 was calculated (AR1=1/T1post-1/T1pre, where T1pre is T1 after contrast injection and T1post is T1 pre-contrast). Paired T-test and ANOVA were used for the statistical evaluation.

Results:
Both the double and the triple doses resulted in a significant decrease of T1 values in the meniscus. As expected, the triple dose yielded lower T1 values than the double dose, from >600 pre-contrast to 280±56 at 180 minutes compared to 347±49 when the double dose was used.

AR1, reflecting tissue Gd-DTPA²⁻ concentration, increased in both the medial and lateral meniscus between 60-120 minutes (p<0.001). No further increase occurred between 120-180 minutes. The temporal dynamics of Gd-DTPA²⁻ distribution into lateral meniscus and femoral cartilage is illustrated in Figure 1. Figure 1 also demonstrates a significantly higher Gd-DTPA²⁻ concentration in the meniscus compared to the femoral cartilage, as was the case also medially (p<0.05-0.001).

Discussion:
In this study of Gd-DTPA²⁻ transport into the meniscus, the diffusion pattern was similar between the meniscus and femoral cartilage, with a continuous wash-in until approximately 120 minutes after injection. Notably, the concentration of Gd-DTPA²⁻ was 2.2-2.8 times higher in the meniscus than in the cartilage, as shown from the AR1 values. This may reflect that the meniscus contains less GAG (FCD) than the femoral cartilage, as supported by several studies of molecular content in canine and human meniscus. The higher Gd-DTPA²⁻ concentration in the meniscus could also be explained by a larger contact area with synovial fluid, i.e. that the diffusion occurs from both sides of the meniscus. In vitro experiments with higher resolution (higher field strength) are needed to confirm this hypothesis.

The faster diffusion in the peripheral than the central part of the meniscus is probably explained by the fact that only the peripheral part is vascularised. The lower concentration of Gd-DTPA²⁻ in the lateral compared to the medial meniscus was unexpected but may reflect structural differences, such as differences in GAG content. This, on the other hand, may reflect different loading between the two compartments. In summary, the present study demonstrates that dGEMRIC of the meniscus is feasible and that the meniscus can be analyzed at the same time as the cartilage, approximately 2 hours after contrast injection. As a next step, the distribution pattern into diseased meniscus needs to be established.