Delayed Gadolinium Enhanced MRI of Cartilage (dGEMRIC) in Hip Dysplasia

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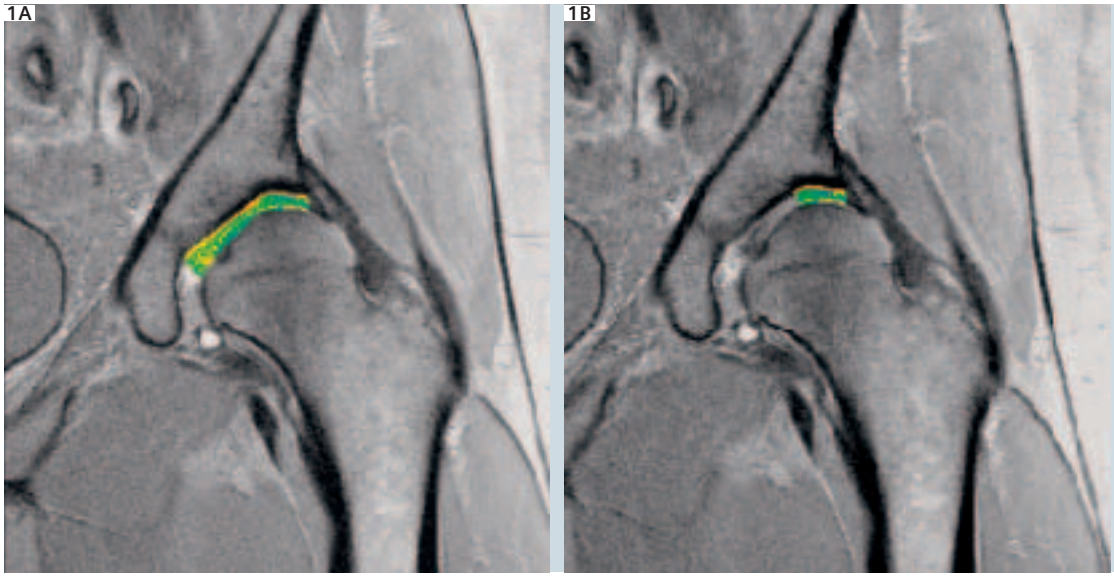
Developmental dysplasia of the hip results in a shallow and unstable hip joint that leads to early osteoarthritis (OA) because of an increased mechanical stress of the cartilage [1–3]. It is estimated in some clinical series that up to 20 % of hips undergoing total hip replacement is due to this developmental disorder [4].
The delayed Gadolinium Enhanced MRI of Cartilage (dGEMRIC) is a non-invasive imaging technique that is able to monitor the loss of charge density in articular cartilage seen in early OA. dGEMRIC is a better marker of OA in hip dysplasia than traditional X-Ray measurements, such as minimal joint space width. Only dGEMRIC correlates with the patient's symptoms and with the severity of dysplasia [5].
dGEMRIC examines the cartilage's fixed-negative-charge density comprised of negatively charged glycosaminoglycans (GAG) [6, 7]. GAG provide the cartilage with its compressive stiffness and are lost early in the course of osteoarthritis [8].
In dGEMRIC, the anionic contrast agent gadopentetate ($Gd\text{-}DTPA^{2-}$), is given intravenously and distributes in cartilage in an inversely proportional manner to the concentration of negatively charged GAG. The concentration of $Gd\text{-}DTPA^{2-}$ will be relatively low in normal cartilage with abundant GAG and will be relatively high in degraded cartilage from which GAG have been lost. The concentration of $Gd\text{-}DTPA^{2-}$ in tissues can be determined from magnetic resonance measurements of T1, with T1 being proportional to the cartilage GAG content. Several in vitro and in vivo validation studies have been performed in the past [6, 9–13].
The dGEMRIC scans are performed with a 1.5T Siemens MAGNETOM Avanto scanner after administration of a double dose (0.4 mL/kg) of intravenous Magnevist ($Gd\text{-}DTPA^{2-}$; Berlex Laboratories, Wayne, NJ, USA) thirty minutes prior to the study [12]. Patients are required to walk for 10 to 15 minutes.
The dGEMRIC value is calculated as the average of the T1 values of the acetabular and femoral head articular cartilages in the weight-bearing zone (as designated from the edge of the acetabular rim to the indentation at the site of fovea's attachment to the femoral head) across all 3 coronal slices. Figs. 1 and 2 illustrate examples of dGEMRIC scans. The three



1 **A, B: T1 dGEMRIC of the hip.**
Color-coded T1-map of a left hip. 35-year-old patient with hip dysplasia.
Green color indicating a high dGEMRIC index (good cartilage status and good predictive value for reorientating surgery).

coronal slices cover most of the weight bearing surface of the hip joint. The femoral and acetabular cartilages from the labral edge to the acetabular fossa were included in the analysis.
The scans are performed under the following protocol:

Sequences	Time
Fast T1 localizer TA	*0.13 min*
T2 truefi 3d we sag TA	*1.42 min*
T2 star map 2d cor TA	*5.59 min*
DESS cor TA	*6.42 min*
Psif 2d sag we r75 384 TA	*9.02 min*
Psif 2d sag we n384 TA	*9.02 min*
T2 truefi 3d we sag 0.6 iso TA	*7.45 min*
Pd tse cor TA	*4.58 min*
Pd tse sag TA	*4.58 min*
Fl 3d vibe T1 Map 4 mm cor TA	*5.46 min*
Fl 3d vibe T1 Map 4 mm sag TA	*5.46 min*

Conclusion

Kim et al. demonstrated that the dGEMRIC index correlates with pain and severity of hip dysplasia as a sign of the biochemical integrity in cartilage [5]. In addition it has been shown that this technique is a better predictor of surgical outcome after periacetabular osteotomy (PAO) than plain radiographic and clinical measurements [14]. The T1 value does correlate with severity of dysplasia which is consistent with the increased incidence of early osteoarthritis in severe dysplasia. It is very important for the surgical treatment and outcome in periacetabular osteotomies to know the status of degenerated cartilage and integrity of cartilage in hips with developmental dysplasia to identify poor candidates for this procedure.

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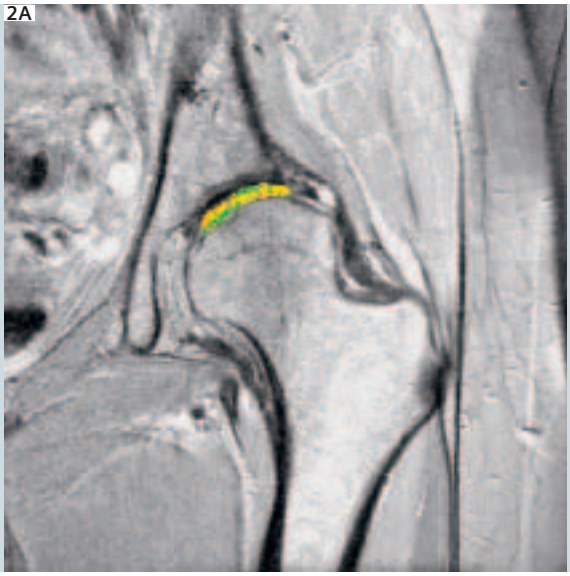

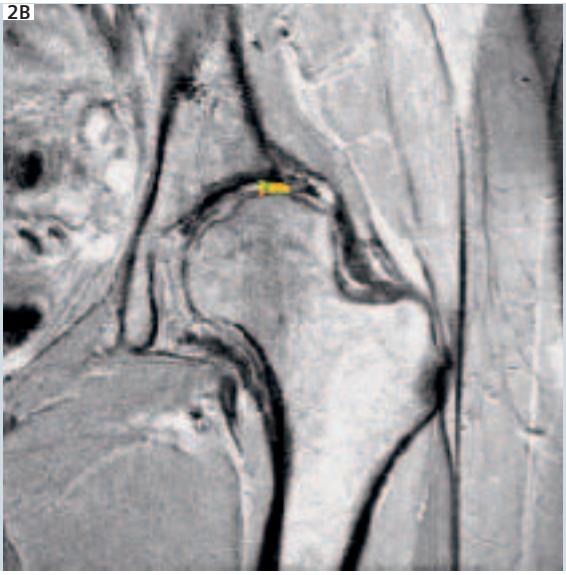

2 A, B: T1 dGEMRIC of the hip. Color-coded T1-map of a left hip. 26-year-old patient with hip dysplasia. Yellow color indicating a lower dGEMRIC index and therefore a cartilage degeneration. This corresponds in this case with osteoarthritic changes in the X-ray images (Tönnis Grade 1–2).