

Delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage is a Predictor of Periacetabular Osteotomy Failure in Patients 40 and Older

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INTRODUCTION: Hip dysplasia leads to abnormal loading of articular cartilage, which results in osteoarthritis. Pelvic osteotomies such as the periacetabular osteotomy (PAO) can improve the mechanics of the joint, but the results are variable and appear to depend on the amount of preexisting arthritis. Delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC) is a technique designed to measure early arthritis, and it potentially could be used to select hips with too severe arthritis to benefit from a joint-preserving reconstructive procedure. Prior studies have shown the correlations between dGEMRIC index and the glycosaminoglycan (GAG) content of articular cartilage with a higher index indicative of more GAG content (healthier cartilage). There are also some reports on the utility of dGEMRIC index to document cartilage health prior to hip preservation surgery in an effort to predict treatment success in preventing the need for total hip replacement. The objective of this study was to investigate the role of preoperative dGEMRIC in predicting the success of PAO in patients 40 and above. We hypothesized that patients who failed had lower preoperative dGEMRIC index compared to those who did not.

METHODS: Following IRB approval, patients 40 or older who underwent PAO between 1990-2013 in our institute and had an available preoperative dGEMRIC scan and a minimum follow-up of 4 years were identified. Patients with prior hip surgeries or any pathologies other than hip dysplasia were removed leading to a total of 70 patients (Age: 44.2 ± 2.9 years old, BMI: 25.7 ± 4.5 Kg/m²). We only included the first hip undergoing PAO for those with bilateral PAO. Out of 70, 19 had failure defined by the need for total hip replacement or WOMAC pain score of 10 and above within 10 years after index PAO surgery. Femoroacetabular articular cartilage was segmented in 3D on a 6 echo fast-spin-echo MRI sequence which was done preoperatively and after intravenous injection of the contrast agent (gadolinium diethylene triamine penta-acetic acid [Gd-DTPA²⁻])-Figure 1A. The segmented masks were used to calculate average thickness and dGEMRIC index across the whole articular surface as well as within 6 subset regions (Figure 1B). The mixed-linear model was after adjusting for baseline parameters and demographics.

RESULTS: There were significant differences in dGEMRIC index between hips that failed (due to pain or need for total hip replacement) and those who survived the whole follow-up period (Figure 1). On average, failed hips had a lower dGEMRIC index by 115 ± 20 ms ($P < 0.001$; Figure 1D). All but one failed hips had a dGEMRIC index of 400 or less (range: 313 – 479 ms), while all the survived hips had a dGEMRIC index of greater than 400 (range: 403 – 691 ms). Similar trends were observed when comparing the dGEMRIC index within the 6 subgroups (Figure 1E; $P < 0.01$). There were no differences in cartilage overall thickness (combined femoral head and acetabular cartilage) between the failed and survived hips ($P > 0.2$).

DISCUSSION: The current data highlights the incorporation of the preoperative dGEMRIC MRI in the clinical decision-making process of older adults undergoing hip preservation surgery. Patients with a high dGEMRIC index (indicating high GAG content) may have a higher chance of successful outcomes following PAO, whereas those with a lower dGEMRIC index (indicating low GAG content and prearthritic OA) may be better candidates for alternative treatment to avoid health complications and financial burden associated with hip preservation (PAO) surgery which ultimately has to be revised or replaced with total hip replacement in short-term. Current efforts are underway to develop a multi-modal predictive model to evaluate risk of failure after PAO based on an array of preoperative imaging and non-imaging outcomes to guide the treatment choice of patients with hip dysplasia.

SIGNIFICANCE: Preoperative dGEMRIC MRI has high clinical value for personalized treatment planning of older adults with hip dysplasia to identify those who will benefit from a PAO surgery versus those who better fit alternative treatments.

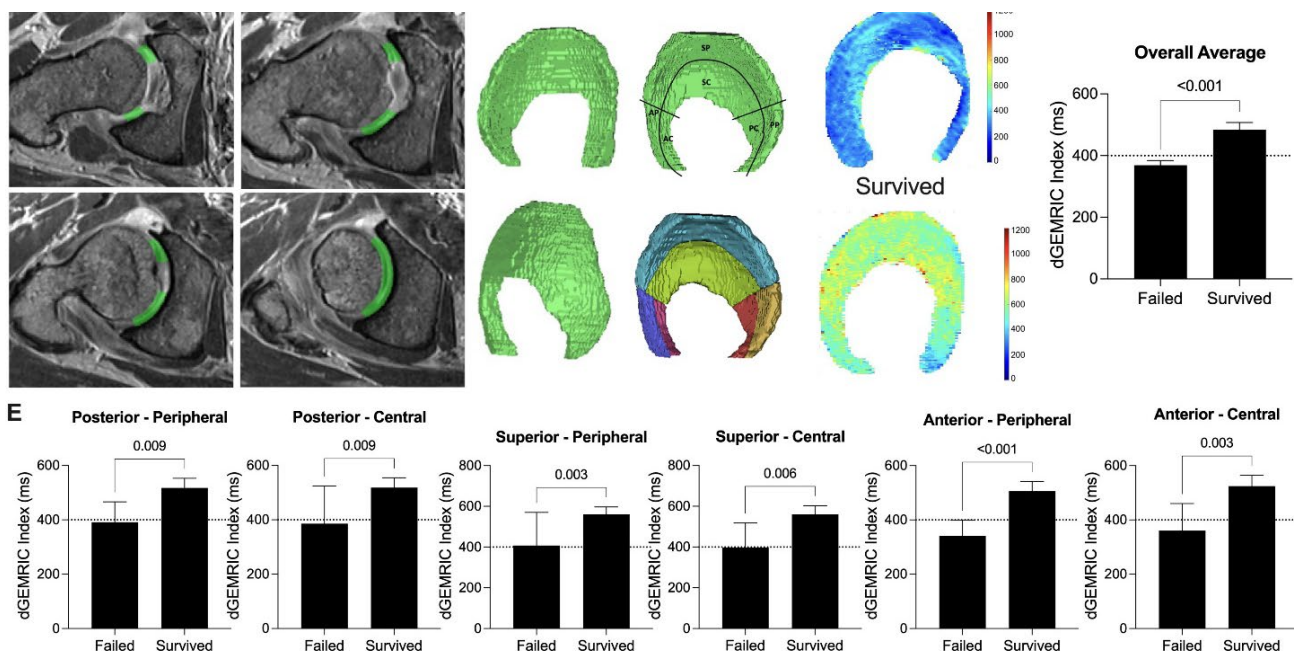


Figure 1. (A) 3D segmentation and model development. (B) Subregion selection. (C) Representative dGEMRIC maps of a hip with eventual need for total hip replacement (failed) and a hip that has survived. (D) The difference in overall dGEMRIC index. (E) Regional differences in dGEMRIC index.