

Single-slice dGEMRIC as a predictor of early failure after a periacetabular osteotomy in hip dysplasia

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Introduction:

Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) is a method to assess cartilage quality by measuring the content of glucosaminoglycans (GAG) [1]. The GAG content is estimated by measuring cartilage T1 values in the presence of the contrast agent Gd-DTPA²⁻ (T1_{Gd}). A previous study on patients with hip dysplasia, a skeletal deformity leading to early osteoarthritis (OA), showed that the dGEMRIC index correlates with pain and the severity of the dysplasia whereas plain radiographs showed no such correlations [2]. Pelvic osteotomies such as the Bernese Periacetabular Osteotomy (PAO) are performed to improve the mechanics of the joint. The purpose of this study was to assess the potential of the dGEMRIC index, as a measure of OA, to select hips with arthritis too advanced to benefit from a joint preserving surgery. T1_{Gd} in four different 4mm thick coronal slices were obtained. In addition to looking at the average dGEMRIC index across four slices, we additionally investigated if the prognostic information from a single slice was equivalent in to the average dGEMRIC index.

Materials and methods:

55 dysplastic hips from 51 patients underwent a PAO from October 1999 to November 2002. The age at time of surgery ranged from 9 to 47 years (mean: 28 years). A pre-operative dGEMRIC scan was performed with the use of a General Electric (Milwaukee, Wisconsin) 1.5-T clinical scanner. A double dose (0.4 mL/kg) of the contrast agent Magnevist (Gd/DTPA²⁻, Berlex Laboratories, Wayne, New Jersey), was injected intravenously approximately 30 minutes prior to the MRI. A multislice fast-spin-echo sequence was used to obtain four coronal T1 maps of the hip with use of the saturation recovery technique, with TE: 14 ms, and TI: 300, 500, 750, 1000, 1500 and 2000 ms. Each slice was 4 mm thick with 1mm spacing between slices. Slice 1 was located most posterior and slice 4 was located most anterior in the hip joint. T1_{Gd} was calculated in a region of interest (ROI) that included the weight bearing acetabular and femoral cartilage (Figure 1). The dGEMRIC index was analyzed for each slice separately and as the mean value of all four slices (average). Pain was assessed with the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) score at the time of the MRI. Radiographic parameters including minimal joint space width, lateral center-edge angle (LCE-angle), joint subluxation, determined by a break in Shenton's line, and Tönnis grade were assessed with a standing AP pelvic radiograph. A hip was considered to have failed if they underwent a total joint replacement. Univariate analysis was used to determine if the pre-operative radiographic and MRI factors were associated with failure. Based on univariate results, a multiple logistic regression analysis using backward selection was performed to determine independent predictors of early failure.

Results:

As previously shown, WOMAC pain was found to negatively correlate to the average dGEMRIC value and positively correlated to minimum joint space width. When correlation between individual slices and pain and joint space width were assessed, the strongest correlation to pain was found in slice 2, $R^2=0.121$, $p<0.05$ (Figure 2). There was a positive correlation between the minimum joint space width and all five dGEMRIC values. Of the 55 hips included in this study five required total hip arthroplasty during the follow up period of nearly four years resulting in a re-operative rate of 9%. The univariate analysis showed that Tönnis grade, joint subluxation, age, and dGEMRIC index were significantly associated with failure. The multiple regression model showed that the pre-operative dGEMRIC value is the single independent factor associated with early joint failure. Furthermore, of the four coronal MRI slices, slice 2 is the best predictor of early postoperative failure after a PAO. Figure 3 shows the probability of a joint replacement after a PAO based on pre-operative dGEMRIC values.

Fig. 1

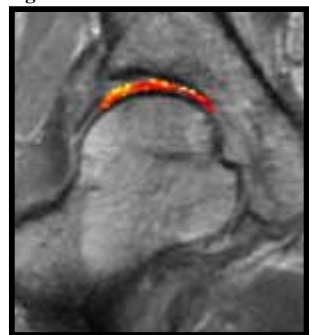


Figure 1: T1 map of the ROI including the weight bearing acetabular and femoral cartilage in a dysplastic hip.

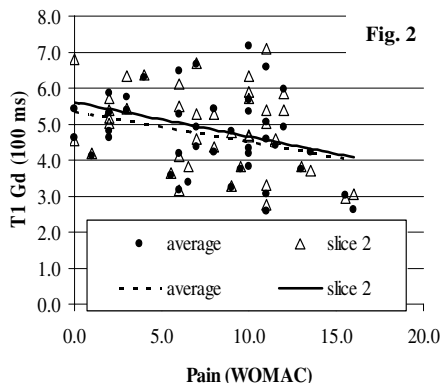


Figure 2: Correlation between pain and the dGEMRIC index for the average of the multislice protocol, and for the most central slice (slice 2) alone. The correlation was similar between the average and slice 2, $R^2=0.092$ and $R^2=0.121$, respectively, ($p<0.05$).

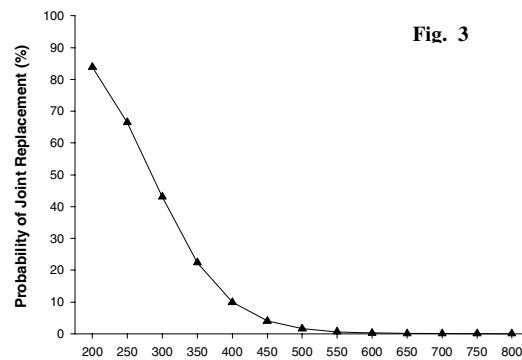


Figure 3: Calculated probability of needing a secondary arthroplasty vs. dGEMRIC index

Discussion:

The present study confirms previous data showing that the dGEMRIC index correlates with clinically relevant parameters, such as pain and joint space width [2]. Moreover, this study illustrates the clinical applicability of the dGEMRIC index as a tool to evaluate a patient's eligibility and potential success for surgery. The average dGEMRIC index as well as slice 2, as an early measure of OA, appears to help identify patients who will not benefit from a joint reconstruction procedure. We show that the analysis of one central slice over the hip joint (slice 2) provides similar information as the average dGEMRIC index of all hip joint cartilage. The decreased correlation seen in the anterior slices with pain may be due to partial volume artifact from the synovial fluid and the convex shape of the femoral head. Such methodological error decreases with the use of one centrally positioned slice. A potential drawback with a single-slice protocol would be that focal cartilage lesions could not be detected. However, the present data do not support this, but rather indicates that hip dysplasia causes global cartilage degeneration. We therefore conclude that, in patients with hip dysplasia, dGEMRIC is a good tool for identifying patients who could greatly benefit from a PAO. It is also possible to conserve resources and utilize one central slice instead of the average of a multislice protocol. In addition to reduced methodological errors, such as partial volume effects, a one-slice protocol reduces the scanning time and hence the costs.

References:

[1] Burstein D et al., Magn Reson Med 2001 45(1):36-41. [2] Kim YJ et al., J Bone Joint Surg Am 2003; 85-A: 1987-92.