Preoperative Delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage (dGEMRIC) for Patients Undergoing Hip Arthroscopy

Indices Are Predictive of Magnitude of Improvement in Two-Year Patient-Reported Outcomes

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Background: Delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC) has been used in the detection of chondropathy. Our study aimed to determine whether dGEMRIC indices are predictive of two-year patient-reported outcomes and pain scores following hip arthroscopy.

Methods: Between August 2008 and April 2012, sixty-five patients (seventy-four hips) underwent primary hip arthroscopy with preoperative dGEMRIC and a minimum of two years of follow-up. Exclusion criteria were previous hip surgery, slipped capital femoral epiphysis, inflammatory arthropathy, Legg-Calvé-Perthes disease, and arthritis of >1 Tönnis grade. Patients were classified in two groups on the basis of a dGEMRIC cutoff of 323 msec, which was one standard deviation (SD) below the study cohort mean dGEMRIC index of 426 msec. Patient-reported outcome tools used included the modified Harris hip score (mHHS), the Nonarthritic Hip Score (NAHS), the Hip Outcome Score Activities of Daily Living (HOS-ADL), and the Hip Outcome Score Sport-Specific Subscale (HOS-SSS) as well as a visual analog scale (VAS) for pain and a patient satisfaction score.

Results: There were sixty-four hips that met the inclusion criteria; fifty-two (81.3%) had a minimum of two years of follow-up. Twelve of the sixty-four hips had a dGEMRIC index of <323 msec (Group 1), and fifty-two hips had a dGEMRIC index of ≥323 msec (Group 2). There was no significant difference between the groups with respect to age, sex, and body mass index. There was no significant difference between the groups in mean preoperative patient-reported outcome scores and the VAS for pain. At the two-year follow-up, Group 1 had significant improvement in the mHHS, whereas Group 2 demonstrated significant improvement in all patient-reported outcome scores and the VAS. The improvement in all patient-reported outcome scores was significantly larger for Group 2 compared with Group 1. There was no significant difference in patient satisfaction between groups and no significant correlation between dGEMRIC indices and the patient-reported outcome measures.

Conclusions: Patients with a dGEMRIC index of ≥323 msec (less than one SD below the cohort mean) demonstrated significantly greater improvement in patient-reported outcome scores and the VAS for pain after hip arthroscopy.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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The severity of osteoarthritis has been shown to adversely affect outcomes following hip arthroscopy[1-6]. Byrd and Jones reported that seven (88%) of eight patients in their study cohort who had clinical findings of arthritis at the time of labral repair underwent conversion to total hip arthroplasty at a mean of sixty-three months[1]. In comparison, fifteen (83%) of eighteen patients without arthritis had a successful outcome at the ten-year follow-up. Philippon et al. observed that patients over the age of fifty years with a joint space of <2 mm, indicative of chondral loss, had poorer outcomes following hip arthroscopy[7]. Other studies have shown that chondral loss not only is associated with poorer outcomes[8] but also increases the duration of rehabilitation in patients undergoing hip arthroscopy[5].

Advances in imaging have increased sensitivity in the detection of chondral pathology. Magnetic resonance imaging (MRI) has been shown to be a reliable and reproducible tool in assessing cartilage changes in the hip[9]. Magnetic resonance arthrography (MRA) with the use of intra-articularly injected gadolinium enables better identification of labral tears and cartilage defects through contrast medium filling of tears and clefts[10,11]. However, MRI and MRA are only useful in the assessment of macroscopic cartilage damage and give no indication of biochemical abnormalities that may be a precursor to chondromalacia[12]. The technique of delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) enables the evaluation of early cartilage changes in osteoarthritis[13]. The technique is sensitive to the charge density of cartilage contributed by glycosaminoglycans (GAGs) that are important structural components of cartilage and relevant for maintaining the intrinsic mechanical properties that are lost early in the process of osteoarthritis[13]. Other methods of detecting chondropathy, such as T2 mapping, also exist, but the utility of those methods in hip preservation has not been as well explored as that of dGEMRIC[13]. The cost-effectiveness of dGEMRIC over conventional MRI has not yet been reported in the literature, to our knowledge.

Kim et al. used dGEMRIC to define early osteoarthritis in patients with hip dysplasia[14]. For cartilage in nondysplastic hips (defined as those with a lateral center-edge angle of >20°) without symptoms, in patients with a mean age of thirty-seven years, they determined that the mean dGEMRIC index was 570 ± 90 msec. Osteoarthritis was defined as an index of <390 msec, two standard deviations (SDs) below the dGEMRIC index of healthy cartilage. The risk of failure after a pelvic osteotomy was demonstrated to increase steeply for hips with a dGEMRIC index of <390 msec, supporting the validity of this minimum index.

The aim of our study was to determine whether dGEMRIC indices of chondral damage correlate with patient-reported outcomes following hip arthroscopy at two-year minimum follow-up. We hypothesized that higher dGEMRIC values, indicating a lower severity of chondromalacia, would be associated with greater improvements in patient-reported outcome measures.

Materials and Methods

Patient Selection

Patients who underwent primary hip arthroscopy between August 2008 and August 2012, and who had a preoperative dGEMRIC scan of the hip and a minimum of two years of follow-up, were included in the study. The indication for hip arthroscopy was hip (groin) pain due to labral tears, with or without femoroacetabular impingement (FAI) or instability. Exclusion criteria were previous hip surgery, slipped capital femoral epiphysis, inflammatory arthropathy, Legg-Calvé-Perthes disease, and arthritis of >1 Tönnis grade[15]. Institutional review board approval was received for the study. During the study period, sixty-five patients (seventy-four hips) had dGEMRIC scans. Fifty-six of the patients (sixty-four hips) met the inclusion criteria.

Intraoperative Procedures

Intraoperative procedures performed in the central, peripheral, and peritrochanteric compartments were recorded. Pincer impingement was treated with acetabuloplasty, and cam impingement was treated with femoroplasty. Labral lesions were debrided, repaired, or reconstructed with autograft or allograft, depending on the lesion size and available labral tissue for repair. Iliopsoas release was performed in patients with symptomatic internal snapping or a positive iliopsoas impingement sign on the labrum. The capsule was repaired routinely, except in patients in whom a release was considered to be therapeutic, such as patients with stiff hips or thickened capsules. Peritrochanteric procedures included trochanteric bursectomy,

TABLE I Demographic Characteristics*

	All Hips, N = 64	Group 1, N = 12	Group 2, N = 52	P Value
Age† *(yr)*	41.95 ± 12.53	45.20 ± 8.27	41.19 ± 13.27	0.32
Sex *(no.)*				0.10
Male	13	5	8	
Female	51	7	44	
Body mass index† *(kg/m²)*	25.80 ± 4.84	25.80 ± 4.33	25.81 ± 5.00	0.99
dGEMRIC index†	426.4 ± 102.8	284.7 ± 35.0	459.1 ± 83.5	
Follow-up *(no. [%])*	52 (81%)	10 (83%)	42 (81%)	0.84

*Group 1 consisted of patients with a dGEMRIC index of <323 msec, and Group 2 consisted of patients with a dGEMRIC index of ≥323 msec, with 323 being 1 SD below the mean. †The values are presented as the mean and the standard deviation.

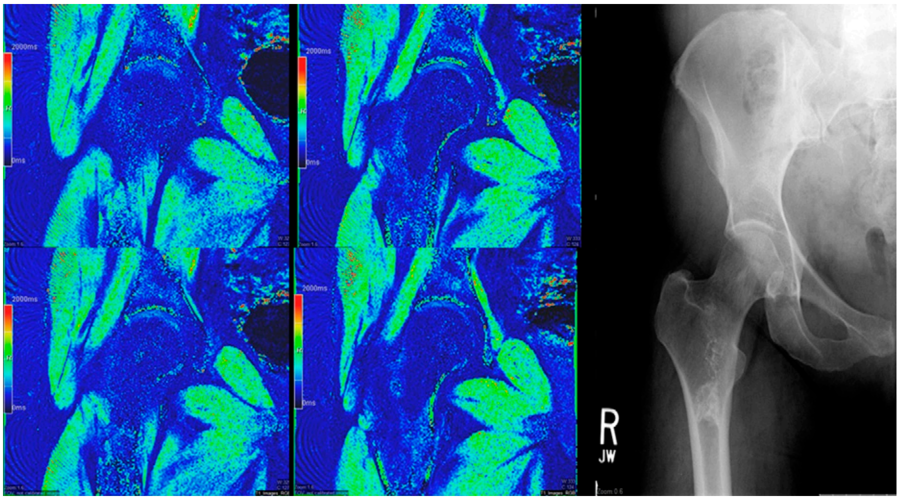

Fig. 1
The zonal variation of fixed-charge density in articular cartilage on dGEMRIC scans of a patient with an average index of 503 msec. This patient has a normal dGEMRIC index, suggesting no osteoarthritis at the molecular level.

repairs of the gluteus medius and the gluteus minimus, and fractional lengthening of the iliotibial band.

Postoperative rehabilitation was tailored to the specific intraoperative procedure performed. Specifically, most procedures required 20 lb (9 kg) of toe-touch weight-bearing for two weeks and the application of a hip abduction brace for two weeks. The only difference in the rehabilitation protocol was for patients who had undergone a microfracture or gluteus medius repair; toe-touch weight-bearing was required for eight weeks and six weeks, respectively. A four-month physical therapy regime was the same for all patients. All patients were advised to avoid painful activities or motions and to participate in sports or activities within the tolerance of their hip. Beyond this advice, no patients were instructed on activities of daily living outside of these standard protocols, as the aim of the hip arthroscopy was both joint preservation and restoring function and quality of life to patients.

dGEMRIC Technique

The dGEMRIC scans were performed with use of a 1.5-T clinical scanner (GE Healthcare, Waukesha, Wisconsin). Patients were intravenously administered a double dose (0.4 mL/kg) of the U.S. Food and Drug Administration (FDA)-approved contrast agent Magnevist (gadolinium diethylenetriamine pentaacetic acid [$Gd\text{-}DTPA^{2-}$]; Berlex/Bayer HealthCare Pharmaceuticals, Wayne, New Jersey). The patients were instructed to walk for thirty minutes after the injection, prior to the scan, to maximize penetration of the gadolinium into the articular cartilage[16]. A multislice, fast-spin-echo sequence was used to obtain coronal slices (saturation recovery technique; echo time, 14 msec; repetition times, 300, 500, 750, 1000, 1500, and 2000 msec). Each slice was 4 mm thick with 1-mm spacing between slices. A T1 map was obtained by fitting the saturation recovery curve to the varying image intensity as the repetition time was varied. The dGEMRIC index was calculated as the average T1 value of the acetabular and femoral head cartilage in the

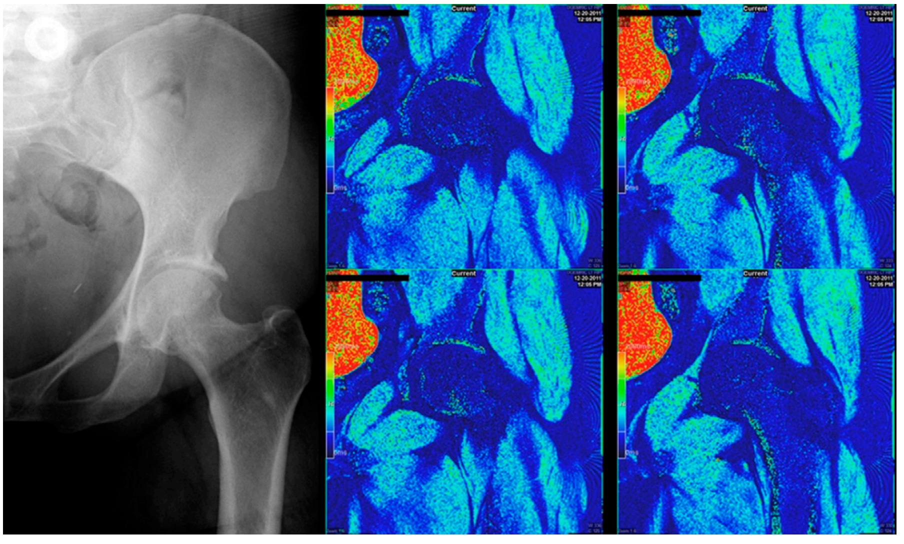

Fig. 2
The zonal variation of fixed-charge density in articular cartilage on dGEMRIC scans of a patient with an average index of 286.9 msec. This patient has a low dGEMRIC index, suggesting osteoarthritis at the molecular level.

TABLE II Comparison of Intraoperative Diagnoses and Findings

	All Hips	Group 1	Group 2	P Value
Seldes labral tear type[29]*				
0	0	0 (0.0%)	0 (0.0%)	
1	33	4 (33.3%)	29 (55.8%)	0.16
2	20	3 (25.0%)	17 (32.7%)	0.86
3	11	5 (41.7%)	6 (11.5%)	0.04
Mean size of tear[30]†	2.7	3.5	2.5	0.01
ALAD grade[19]*				
0	3	0 (0.0%)	3 (5.8%)	0.92
1	13	1 (8.3%)	12 (23.1%)	0.46
2	29	4 (33.3%)	25 (48.1%)	0.36
3	15	6 (50.0%)	9 (17.3%)	0.04
4	3	0 (0.0%)	3 (5.8%)	0.92
Ligamentum teres Domb classification[31]*				
0	20	4 (33.3%)	16 (30.8%)	0.86
1	24	5 (41.7%)	19 (36.5%)	1.00
2	15	2 (16.7%)	13 (25.0%)	0.81
3	3	1 (8.3%)	2 (3.9%)	0.92
Femoral Outerbridge classification[32]*				
0	46	7 (58.3%)	39 (75.0%)	0.42
1	0	0 (0.0%)	0 (0.0%)	
2	7	2 (16.7%)	5 (9.6%)	0.85
3	3	1 (8.3%)	2 (3.9%)	0.92
4	3	2 (16.7%)	1 (1.9%)	0.16

*Values are presented as the number of hips with the percentage of the group in parentheses. ALAD, ligamentum teres, and Outerbridge classifications not available for some patients. †Values are presented as hours on the acetabular clock face.

weight-bearing zone (as designated from the edge of the acetabular rim to the indentation at the site of the attachment of the fovea to the femoral head) across all coronal slices[14] (Figs. 1 and 2). A normal dGEMRIC index (and SD) is 570 ± 90 msec[17].

Grouping Based on dGEMRIC Indices

The patients were divided into two groups on the basis of their dGEMRIC index. This division was established by first calculating the mean and SD of the dGEMRIC indices of all of the study cohort patients. Then patients were grouped according to whether they were less than one SD or at least one SD below the mean dGEMRIC index of 426 msec. The rationale behind this grouping of patients is based on the dGEMRIC assessment of early osteoarthritis in patients with hip dysplasia by Kim et al.[14].

Patient-Reported Outcome Scores

All data were prospectively collected and retrospectively reviewed. Patient-reported outcome scores were obtained preoperatively and at two years postoperatively. The outcome measures were the modified Harris hip score (mHHS), the Nonarthritic Hip Score (NAHS), the Hip Outcome Score Activities of Daily Living (HOS-ADL), and the Hip Outcome Score Sport-Specific Subscale (HOS-SSS). In addition, pain was measured by a visual analog scale (VAS) from 0 to 10 (with 0 indicating no pain and 10, severe pain). Patient satisfaction was also recorded on a scale of 0 to 10 (with 0 being completely unsatisfied and 10, completely satisfied). A patient satisfaction score of >7 was considered a good to excellent outcome[18]. The senior author evaluated and performed surgery on all patients in the study cohort.

Statistical Analysis

Univariate analysis was used to compare demographic data between the two groups. We used quantile plots to determine whether the change in the four patient-reported outcome scores and VAS for pain followed a normal distribution. The plots were linear (see Appendix), suggesting a normal distribution. Therefore, an unpaired Student t test was used to compare differences in mean outcome scores between the two groups. The correlation between dGEMRIC indices and the amount of change between preoperative and postoperative patient-reported outcomes, VAS, and patient satisfaction for the entire cohort was determined with use of the Spearman correlation coefficient to account for potential nonlinear correlations. A p value of <0.05 was considered significant.

Source of Funding

There was no external source of funding for this investigation.

Results

Patient Demographics

Fifty-six patients (sixty-four hips) met the inclusion criteria (see Appendix). Ten patients (twelve hips) were lost to follow-up, and four patients converted to total hip arthroplasty, leaving forty-two patients (forty-eight hips) with two-year follow-up. Including the four conversions, outcomes were assessed for fifty-two (81.3%) of sixty-four hips. The mean

TABLE III Arthroscopic Procedures Performed

	All Hips	Group 1	Group 2	P Value
Intra-articular procedures				
Acetabuloplasty	33	6	27	0.90
Femoral osteoplasty	45	11	34	0.15
Iliopsoas release	22	6	16	0.35
Synovectomy	4	1	3	0.74
Ligamentum teres debridement	34	6	28	0.81
Removal of loose body	11	3	8	0.71
Excision of bone cyst, acetabulum	1	0	1	0.42
Excision of bone cyst, femur	3	1	2	0.92
Removal of os acetabuli	1	0	1	0.42
Notchplasty	5	2	3	0.50
Chondroplasty				
Acetabular	6	0	6	0.49
Femoral	0	0	0	
Both	3	0	3	0.92
Any	9	0	9	0.27
Labral procedures				
Repair	26	4	22	0.81
Debridement	38	8	30	0.81
Reconstruction	0	0	0	
Conversion to total hip replacement	0	0	4	0.74
Peritrochanteric procedures				
Piriformis release	1	0	1	0.42
Iliotibial band release	4	0	4	0.74
Trochanteric bursectomy	19	1	18	0.15
Gluteus medius repair	10	1	9	0.74

dGEMRIC index for the entire cohort was 426 ± 103 msec. The cohort was divided into two groups on the basis of the index cutoff of 323 msec, which was one SD below the mean (Table I). Group 1 had a dGEMRIC index of <323 msec, and Group 2 had an index of ≥323 msec. There was no significant difference between the two groups with respect to demographic characteristics (Table I).

Intraoperative Findings and Operative Procedures Performed

Table II details the intraoperative diagnoses and findings for the cohort. Table III lists arthroscopic procedures performed. There was no significant difference in arthroscopic procedures performed between the two groups. There were four patients in Group 2 who required conversion to total hip arthroplasty (Table IV). The indication for total hip arthroplasty in all four was ongoing hip pain with radiographic evidence of progression to osteoarthritis of the hip. Three of the four patients had acetabular labral articular disruption (ALAD) of grade 4[19] with exposed subchondral bone. The area of exposed bone ranged from 200 to 300 mm^2. The other patient had an ALAD grade-1 lesion and required total hip arthroplasty approximately six months after the primary arthroscopic procedure. The patient had a dysplastic acetabulum with a lateral center-edge angle of 22°.

TABLE IV Characteristics of Patients Who Required Conversion to Total Hip Arthroplasty within 24 Months of Primary Arthroscopy

Age at Arthroscopy *(yr)*	dGEMRIC Index *(msec)*	Months Until Total Hip Arthroplasty	Comments
40.53	543	17.31	ALAD grade 4
49.34	473.1	15.77	ALAD grade 4
44.23	362.3	16.62	ALAD grade 4
50.80	411	6.14	ALAD grade 1, dysplastic acetabulum

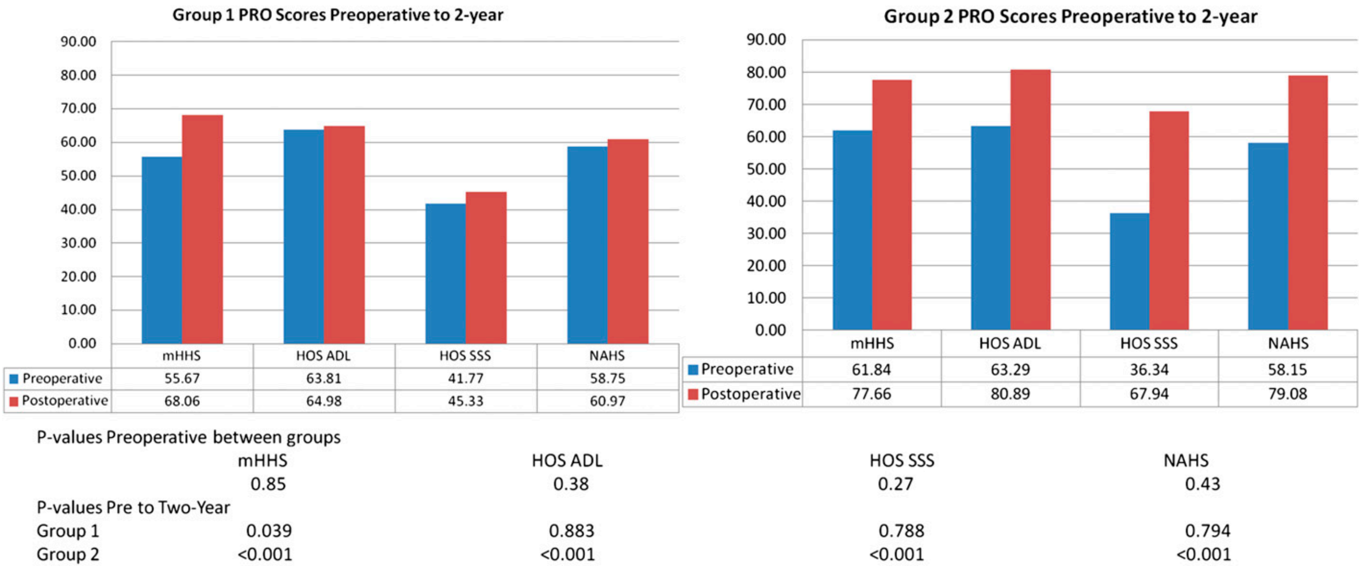

Fig. 3

Preoperative and postoperative scores for Group 1 and Group 2. Group 1 included patients with a dGEMRIC index of <323 msec, and Group 2, an index of ≥323 msec. There was a significant change between preoperative and postoperative scores in Group 1 for only the mHHS and in Group 2, for all patient-reported outcomes (PROs).

Patient-Reported Outcomes

There was no significant difference in the mean preoperative patient-reported outcome scores between Group 1 and Group 2. At the two-year follow-up, Group 1 had a significant improvement in the mHHS but not in the other scores (Fig. 3). In comparison, Group 2 had a significant improvement in all mean patient-reported outcomes (Fig. 3). Group 2 had a significantly larger improvement in all mean patient-reported outcomes compared with Group 1 (Fig. 4).

VAS

There was no significant difference in mean preoperative VAS scores between Group 1 and 2 (Fig. 5). At two years, only Group 2 had a significant improvement in mean VAS scores (Fig. 5). Group 2 also had a significantly larger improvement in mean VAS scores (Fig. 6).

Patient Satisfaction

At the two-year follow-up, the mean patient satisfaction score was 7.6 in Group 2 and 6.0 in Group 1; the difference was not

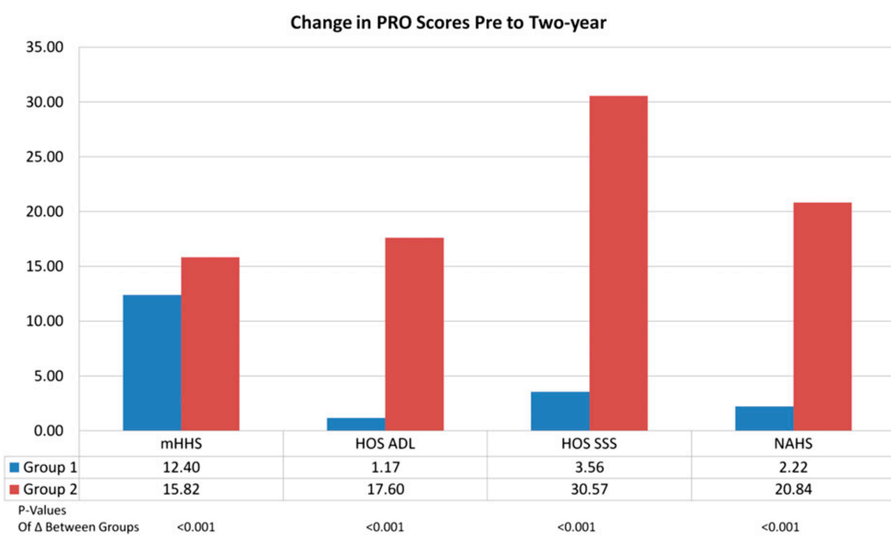

Fig. 4

Improvement (Δ) from preoperative to postoperative patient-reported outcome scores for Group 1 and Group 2. Group 1 included patients with a dGEMRIC index of <323 msec, and Group 2, an index of ≥323 msec. Group 2 had a significantly larger improvement in all reported patient-reported outcomes (PROs) compared with Group 1.

TABLE V Correlation Coefficients Between dGEMRIC Indices and Outcomes for the Entire Cohort

	mHHS	HOS-ADL	HOS-SSS	NAHS	VAS
Spearman rho	−0.22	0.24	0.24	0.11	−0.07
P value	0.14	0.11	0.11	0.47	0.65

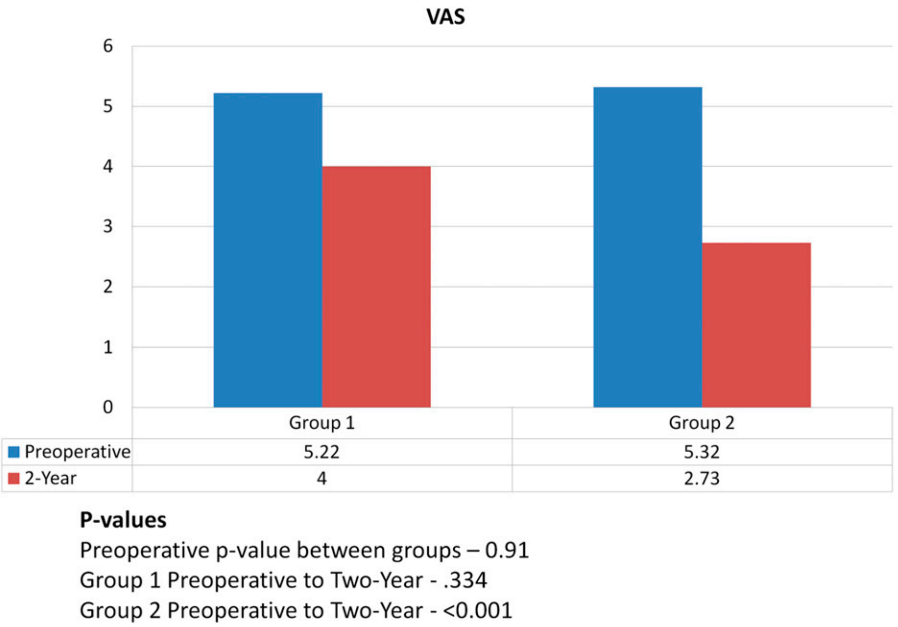

Fig. 5
VAS pain scores for Group 1 and Group 2. Group 1 included patients with a dGEMRIC index of <323 msec, and Group 2, an index of ≥323 msec. There was a significant change between preoperative and postoperative VAS scores for Group 2.

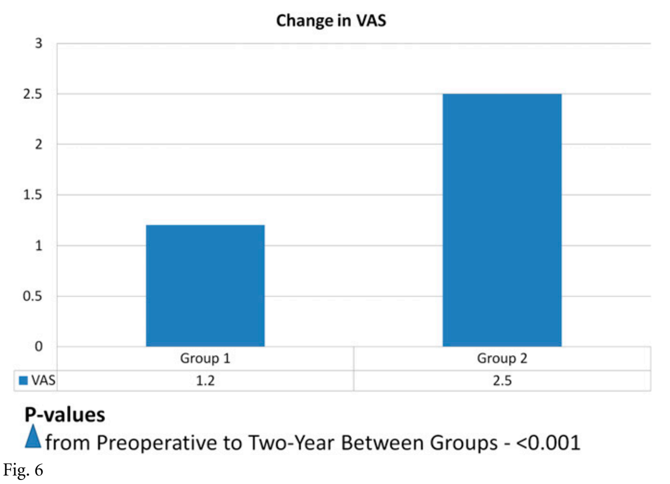

Fig. 6
Improvement (Δ) from preoperative to postoperative VAS score for Group 1 and Group 2. Group 1 included patients with a dGEMRIC index of <323 msec, and Group 2, an index of ≥323 msec. Group 2 had a significantly larger improvement in VAS compared with Group 1.

significant. Twenty-seven (52%) of the fifty-two hips in Group 2 and five (42%) of twelve in Group 1 achieved a good to excellent outcome (a satisfaction score of >7)[18].

Correlation Between dGEMRIC Indices and Patient-Reported Outcomes

There was no significant correlation between dGEMRIC indices and any of the four patient-reported outcome scores (Table V). Additionally, there was no significant correlation between dGEMRIC indices and changes in patient-reported outcome scores for either Group 1 or Group 2.

Discussion

dGEMRIC indices may provide useful clinical information for hip preservation procedures, such as hip arthroscopy, which aim to prevent or delay the progression of cartilage degradation. The results of the current study demonstrated that patients with a dGEMRIC index of ≥323 msec (less than one SD below the cohort mean) had significantly greater improvement in patient-reported outcomes and VAS pain scores after hip arthroscopy. Although this categorical division based on a dGEMRIC index of 323 msec yielded a significant finding, a significant correlation between dGEMRIC indices and improvement in patient-reported outcome scores and VAS for pain was not demonstrated.

The dGEMRIC index has been shown to be a valid measure of joint degeneration and a good predictor of the outcome of acetabular reorientation osteotomy for the treatment of hip dysplasia[14,17,20]. Kim et al. used dGEMRIC to define

TABLE VI Explanation of Patient Selection

	No. of Patients	No. of Hips
dGEMRIC scans	65	74
Did not have arthroscopy	7	7
Previous hip conditions	2	3
Met inclusion criteria	56	64
Lost to follow-up	10	12
Converted to total hip arthroplasty	4	4
2-yr outcomes	42	48
Follow-up incl. conversions to total hip replacement	46 (82.1%)	52 (81.3%)

osteoarthritis as an index of <390 msec, which is two SDs below the index of healthy cartilage[14]. The validity of this cutoff is supported by the finding that risk of failure after pelvic osteotomy increased steeply for hips with a dGEMRIC index of <390 msec. To our knowledge, there are currently no guidelines in the literature to help determine an appropriate dGEMRIC cutoff that may be predictive of outcomes following hip arthroscopy. The current study used one SD below the mean of the cohort index as a cutoff value. An index of 390 msec was not chosen because it was within one SD of the cohort's mean of 426 msec and, as such, would include a substantial proportion of the study population grouped below this cutoff. The lower mean dGEMRIC index in our population may reflect an older study cohort compared with that of Kim et al.[14] but is also consistent with the conclusion of other studies that have reported a significantly lower dGEMRIC index for patients with symptomatic FAI compared with asymptomatic individuals[21,22].

The utility of dGEMRIC indices has been examined for other joint preservation surgeries, particularly those involving the knee. Bekkers et al. reported that clinical scores and dGEMRIC indices showed a significant improvement following reparative cartilage surgery of the knee in thirty-one patients[23]. In the management of anterior cruciate ligament (ACL) injuries, Neuman et al. found that, in their cohort of thirty-two patients, patients who had been treated nonoperatively managed to cope with their ACL injury for twenty years with sustained good subjective knee function also seemed to have knee cartilage of good quality, with dGEMRIC indices not very different from those of a healthy reference group[24].

The results of the current study are supported by other studies that have demonstrated an association between cartilage degeneration and lower outcome scores following hip arthroscopy[1,2,6]. Guanche and Bare noted that two (20%) of ten patients in their study cohort who did not have a successful result after arthroscopy for FAI had degenerative changes at the time of intervention[2]. Stähelin et al. reported that five (23%) of twenty-two patients in their study who had worse postoperative patient-reported outcomes had either grade-1 or 2 Tönnis arthritis[6].

One inconsistency within the current study is that the four patients who required conversion to total hip arthroplasty all had an index of ≥323 msec. The indication for total hip arthroplasty was continued pain with radiographic progression to osteoarthritis of the hip. Three of the four patients who had hip arthroscopy for FAI had an ALAD grade-4 lesion, or exposure of subchondral bone at the labral-chondral junction. A total hip arthroplasty, rather than a revision arthroscopy, was undertaken to best address pain from the extensive chondral damage. One possible explanation for the discrepancy between the dGEMRIC index and intraoperative findings is that the dGEMRIC index requires delineation by the radiologist of a geographic area of cartilage, over which area the index is averaged. The area of the dGEMRIC measurement was in the superior dome of the hip joint. This delineation of geography was arbitrary and did not include areas of common cartilage damage such as the anterosuperior acetabulum. This has been confirmed by Stelzeneder et al., who compared dGEMRIC indices of twenty-one patients who had FAI with those of nineteen patients who had developmental dysplasia of the hip (DDH), finding no significant difference in the occurrence of cartilage damage, bone cysts, or osteophytes between the groups[25]. They reported that, in the DDH group but not in the FAI group, the dGEMRIC index demonstrated a tendency for lower values in areas next to cartilage defects, and there was no association between labral damage and dGEMRIC index.

Ours is the first study, to our knowledge, to assess the value of dGEMRIC in predicting outcomes using patient-reported outcome measures following hip arthroscopy at the two-year follow-up. The strengths of the current study included the prospective nature of data collection as well as the use of four patient-reported outcome measures and the VAS for pain in the reporting of outcomes; there is no conclusive evidence for the use of single patient-reported outcome questionnaires for patients undergoing hip arthroscopy[26,27].

The study also had several limitations, including a small cohort size of sixty-four; however, the cohort size is similar to that of other MRI studies on hip arthroscopy[12]. A small cohort size may potentially contribute to a type-II statistical error, but the study was still able to report a significant improvement in

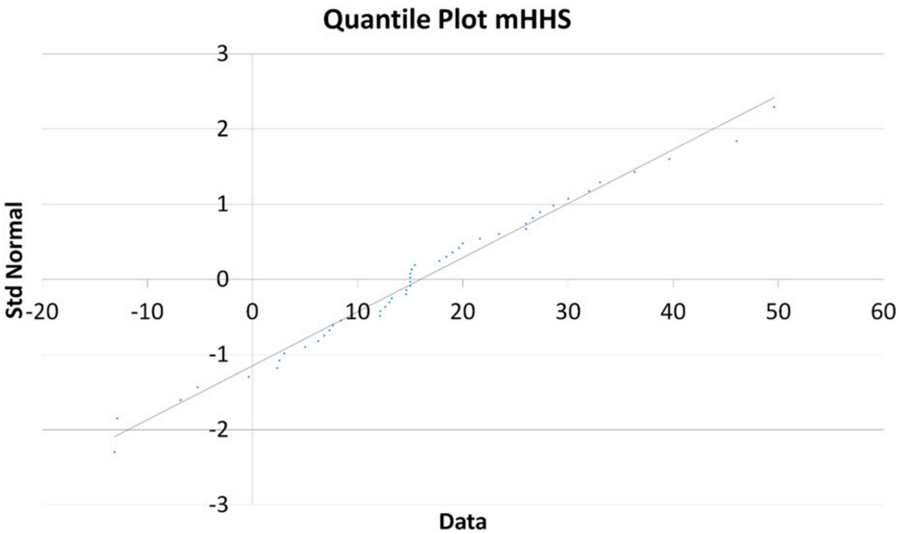

Fig. 7-A

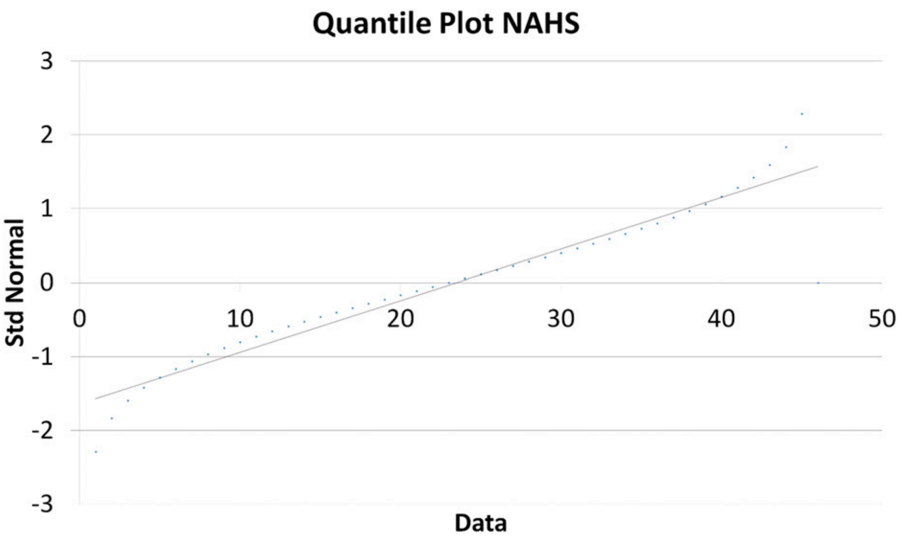

Fig. 7-B

Figs. 7-A through 7-E Quantile plots were used to determine whether the change in the four patient-reported outcome scores (**Figs. 7-A through 7-D**) and visual analog scale (VAS) for pain (**Fig. 7-E**) followed a normal distribution. The plots were linear, suggesting a normal distribution. mHHS = modified Harris hip score, NAHS = Nonarthritic Hip Score, HOS ADL = Hip Outcome Score Activities of Daily Living, and HOS SSS = Hip Outcome Score Sport-Specific Subscale.

patient-reported outcomes and VAS with a dGEMRIC index of ≥323 msec (less than one SD below the cohort mean). The other limitation of the study is that it included patients with bilateral hip arthroscopies, potentially violating the principle of statistical independence. We attempted to correct for this partially by instructing the patient to report outcomes specific to each hip.

Accounting for why the current study did not establish a correlation between dGEMRIC indices and outcomes may be related to the multifactorial and nonlinear nature of patient-reported outcomes. Some of these factors include primary diagnosis, joint-space width, arthroscopic procedures, and cartilage degeneration. We attempted to address these issues by limiting the primary diagnosis to labral tears with or without FAI instability and excluding patients with arthritis of >1 Tönnis grade. In addition, all procedures were performed by a single surgeon. There was no significant difference with respect to arthroscopic procedures performed between the two dGEMRIC index groups. Another study has demonstrated a sex-dependent disease pattern in patients with symptomatic FAI: female patients had more profound symptomatology and milder morphological abnormalities compared with male patients, who had higher activity levels and more extensive intra-articular disease[28].

In conclusion, our findings demonstrated that patients with a dGEMRIC index of ≥323 msec (less than one SD below the cohort mean) had significantly greater improvement in patient-reported outcomes and VAS for pain after hip arthroscopy. This categorical division of patients on the basis of the dGEMRIC index may be useful in predicting the magnitude of improvement following hip arthroscopy.

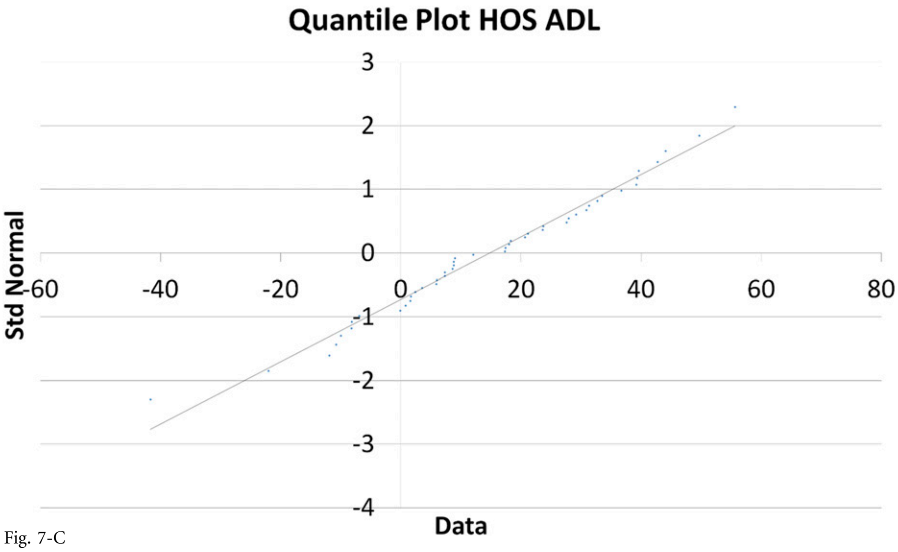

Fig. 7-C

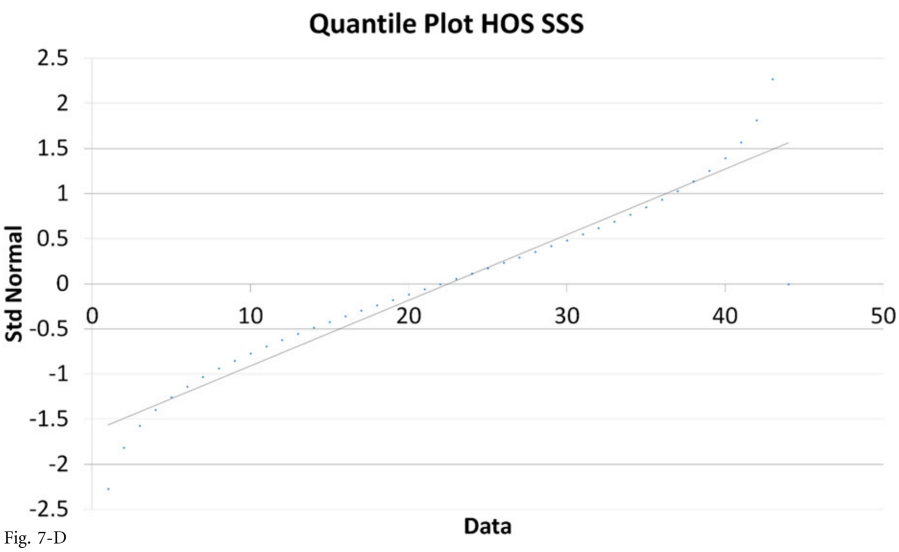

Fig. 7-D

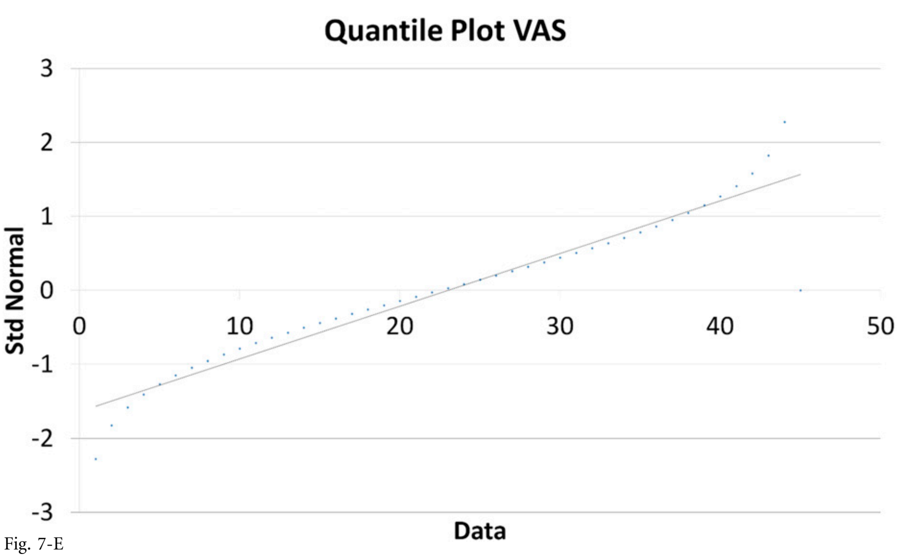

Fig. 7-E

Appendix

Figs. 7-A through 7-E show the quantile plots to test for normality. Patient flow is presented in Table VI. ■

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