INTRODUCTION
Developmental dysplasia of the hip results in a shallow and often unstable hip joint that leads to early osteoarthritis (OA)[1]. By some estimates, up to 20% of hip OA could be due to this developmental disorder[2]. The cause of OA in this condition is thought to be mechanical overloading of the articular cartilage in the shallow acetabulum. Pelvic osteotomies are performed to normalize the hip joint mechanics and there is increasing evidence that osteotomies are able to prevent the progression of OA[3,4]. However, careful study is difficult due to a lack of a sensitive, specific, and noninvasive technique to assess the cartilage damage in OA. The delayed Gadolinium Enhanced MRI of Cartilage (dGEMRIC) was developed to directly monitor charge density changes in articular cartilage seen in early OA. We have applied dGEMRIC to evaluating OA in dysplastic hips[5] and compared dGEMRIC to plain radiographic measurement of joint space narrowing (JSN), the current gold standard.

MATERIALS AND METHODS
All patients were skeletally mature or nearing skeletal maturity (triradiate cartilage closed). All had hip dysplasia but no evidence of neuromuscular disorder or skeletal dysplasia. Hips with prior acetabular osteotomies were excluded. Institutional review board approval and informed consent was obtained for this study. Clinical symptoms were assessed using the Western Ontario McMaster Universities (WOMAC) questionnaire. Standard standing anterior-posterior pelvic radiograph was obtained. JSN was measured as the minimum joint space obtained when measured in the radial direction from the center of the femoral head. The lateral center edge angle (LCE) measures the severity of the dysplasia and is the angle formed by the vertical line through the center of the femoral head and the edge of the acetabulum[1]. The dGEMRIC scans were obtained using a GE 1.5 T clinical scanner. Double dose (0.4 ml/kg) of Magnevist (GdDTPA<sup>2-</sup>) were injected intravenously and the patients were required to walk for 30 minutes prior to the scan[5]. Four coronal slices through the hip joint were imaged using the fast spin echo sequence (FSE). The T1 constant, which measures GdDTPA<sup>2-</sup> concentration, was calculated from these FSE images using saturation recovery technique. The average T1 value of the weight bearing femoral and acetabular cartilages from all 4 slices was calculated and used as an osteoarthritis index. Statistical correlations between T1, JSN, WOMAC Pain, LCE, and Age were assessed using Spearman’s rank correlation.

RESULTS
Normal Hips: Eight hips in eight patients (average age 37 yrs, range 20 - 48 yrs) that were asymptomatic had an average T1 value of 815 msec. These hips were morphologically normal (LCE > 20 deg) and had no plain radiographic evidence of OA.

Repeatability: Five hips that did not undergo surgery were scanned twice within one year to measure the repeatability of the dGEMRIC technique. The differences in T1 values were not significantly different from zero and the standard deviation of the differences was 120 msec.

Correlation with Symptoms and Severity of Dysplasia: Sixty eight hips in 43 patients (average age 30 yrs, range 11-47 yrs) had standing pelvic radiographs, dGEMRIC scans, and outcome assessment. As typical of dysplasia, 40 of the 43 patients were women. Fig. 1 is an example of dGEMRIC scan of a mildly arthritic hip. T1 significantly correlated with WOMAC pain score (r<sub>s</sub>=−0.52, p<0.0001) while JSN did not (Fig. 2). This is despite a significant correlation between T1 and JSN (r<sub>s</sub>=−0.58, p<0.0001). T1 also correlated with WOMAC functional impairment score but not with joint stiffness. T1 correlated with the severity of dysplasia as assessed using the LCE angle (r<sub>s</sub>=−0.51, p<0.0001) (Fig. 3). The significant correlations between T1 vs pain and T1 vs LCE were still valid when partial correlations were calculated to eliminate the contribution of a weak correlation between LCE and pain. JSN did not correlate with LCE. The average T1 value of joints with LCE below the critical value of 16 deg was 656 msec, which is significantly (p<0.0005) lower than the T1 value of normal hips, suggesting loss of cartilage fixed charge density. The loss of cartilage charge density (T1) and JSN did not seem to correlate with the age. However, even in hips with severe dysplasia (LCE < 0, 6 hips in 5 patients) the T1 value did not fall below 2 SD of normal (575 msec) until age 20 years. Similarly, the loss of articular cartilage sufficient to cause OA (JSN < 3mm) never was younger than 25 years of age and none had LCE greater than 16 degrees.

DISCUSSION
The dGEMRIC technique was designed to measure the of fixed charge density in cartilage. This is the first clinical application of this technique to study human OA. The correlation between T1 and symptoms and lack of correlation between JSN and symptoms suggests that dGEMRIC technique provides additional information about a pre-arthritic joint that is not measured by standard radiographs. Furthermore, the data obtained using the dGEMRIC technique appears to be consistent with what we know about OA in hip dysplasia. T1 does correlate with severity of dysplasia, which is consistent with the increased incidence of early OA in severe dysplasia. There was no direct correlation between JSN, T1 and age. However, the drop in T1 below normal level appears to occur at a young age (> 20 years) than onset of OA (> 25 years). This would be consistent with proteoglycan loss being an early event in the development of OA and it is the actual loss of tissue that occurs over time.

At present, this is the only noninvasive technique to directly assess the integrity of the cartilage matrix in vivo. We are currently utilizing this technique to study the response of the dysplastic hip joint after periacetabular osteotomy. However, this technique would be ideal in assessing the efficacy of various disease modifying osteoarthritis drugs.

REFERENCES

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