INTRODUCTION
Legg-Calvé-Perthes disease (LCP), the most important cause of avascular necrosis in children, is a common disorder of childhood, characterized by an idiopathic avascular necrosis of the growing femoral head. The main complication is femoral head deformity, which in turn is one of the main causes of degenerative hip disease, particularly in adult men. Magnetic resonance imaging has provided useful insights by demonstrating the involvement of the bone marrow, the thickening of the synovium that accompanies the disease, the physial abnormalities that lead to growth arrest, and the deficiencies of containment and congruity of the articular surfaces. Except for the evaluation of perfusion, however, the information derived from MRI up to this point has been primarily morphologic and mostly qualitative. Increasingly, however, MR has become capable of identifying abnormalities of function and structure of the cartilage and bone. Line scan diffusion (LSDI) can show early changes related to epiphyseal ischemia, with a progressive increase in apparent diffusion coefficient (ADC) values as the duration of ischemia increases. Research in piglets suggests that at a later stage ADC values return to near normal. Detecting the earliest changes in ischemia, differentiating early from late ischemia leading to avascular necrosis, and to predicting the development of growth arrest are central to establishing a prognosis and planning the therapy for children afflicted with LCP. Our hypothesis is that LSDI in children with LCP will allow a better assessment of the stage of the disease beyond what is possible with radiographs or perfusion MRI.

METHODS
We have imaged 8 boys, ages 2.9 yr to 12.5 yr (median, 5.8yr), with line scan diffusion MRI (LSDI). This line scan diffusion imaging (LSDI) obtains two sets of images for each direction, one with a low diffusion weighting (β factor: 5 sec/mm²) and another with high diffusion weighting (β=750 sec/mm²). Trace ADC images are computed by solving for D using the Stejskal-Tanner approach. We have used relatively low β factor in order to maximize spatial resolution with FOV of 24 to 26 cm.

We used a line scan diffusion sequence with TR/TE = 4000/75 ms, with 1-2.5 mm thick slices covering each joint. Images were acquired at 1.5T (GE Horizon, Milwaukee). We have calculated scalar data, corresponding to the magnitude of the diffusion tensor at each voxel. We measured the ADC in the epiphysis (cartilage and bone together, as they could not be reliably separated, and metaphysis for the abnormal and control hips. T1-weighted images post administration of a Gadolinium-based contrast agent (Magnevist, Berlex, NJ) were also measured in order to assess perfusion (Fig. 1).

The cases were graded as follows, based on the perfusion sequence and the MR images: 1=minimal abnormality; 2=active disease; 3=healing disease; 4=healed disease.

RESULTS
Epiphyseal ADC was 4.7 times greater in the two boys with active disease than in the controls (Fig. 2); in patients with healing LCP it was only 1.6 times greater. In the controls, diffusion was 26% greater in the metaphysis than the epiphysis. Metaphyseal diffusion was 1.9 times greater in the patients with active disease than in the controls. The following images are post Gd MRI and ADC maps (Fig. 3) on a patient with active LCP. Epiphyseal diffusion is markedly increased in comparison to the control. The graphs show the changes in ADC in epiphysis and metaphysis with various grades of disease activity.

DISCUSSION
Diffusion weighted MRI of brain ischemia has been studied extensively and has been shown to demonstrate initial decreased diffusion followed by an increase as tissue destruction ensues. Our initial work in femoral head ischemia [1] suggests the same type of biphasic response. Children with avascular necrosis, usually due to Legg-Calvé-Perthes disease, present after weeks or months of hip pain. The patients studied, therefore, may have been imaged after the changes of the initial period, and we cannot determine whether they had an initial decrease in diffusion. In avascular necrosis of the hip in children, many of the changes occur in association with reperfusion [2]. Gadolinium enhanced images, therefore, can show perfusion even as the collapse of the femoral head and the destruction of the physis continues. Our findings suggest that diffusion-weighted MRI provides information about epiphyseal tissue damage that is not available from perfusion imaging, and thus may help in the management of these patients.

REFERENCES

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DIFFUSION MR IMAGING IN CHILDREN WITH SUSPECTED AVASCULAR NECROSIS OF THE HIP

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Figure 1. Coronal fat-suppressed post-gadolinium T1-weighted image shows absence of enhancement in the ossification center of the left femoral head (arrow).

Figure 2. LSDI images on the same patient show that there is increased diffusion on the affected side (bright femoral head, 2a) compared to the control side (2b) where the femoral head has an ADC similar to that of the metaphysis.

Figure 3. Variation in ADC (Mean ± SD mm²/s) in patients studied for avascular necrosis. The graphs show that the epiphyseal (3a) and metaphyseal (3b) diffusion are highest when the disease is most active, but are close to levels of the control side after healing.

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ADDITIONAL INFORMATION

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