

## Morphological Study of the Femoral Head and Acetabulum using Serial Range of Motion MRI in Legg Calve Perthes Disease in Children

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**Abstract :** We define a Serial Range of Motion MRI (SROM MRI) as a set of MRI images of the hip in 5 standard positions : (neutral, adduction, abduction, abduction internal rotation, and abduction internal rotation flexion). Here we have investigated the usefulness of this technique on an out patient basis, to study the correlation between the femoral head and acetabulum. A total of 99 SROM MRIs were recorded from 78 patients (6 girls, 72 boys ; average age 7.4 years ; 44 pillar B, 55 pillar C). In each case, the epiphyseal extrusion index (EEI), the head coverage (HC), and the medial gap ratio (MGR) were calculated.

When moving from the neutral to the abduction position, the parameters EEI and HC showed significant improvement in all patients. The MGR also improved for both pillar groups, but the improvement was only statistically significant for pillar B ( $p < 0.05$ ). When moving from neutral to adduction, all 3 parameters indicated significant subluxation in the pillar C hips, although the more severely involved hips were actually more congruent in this position. Further subluxation was limited by soft tissue tension on the lateral and medial sides.

SROM MRI performed on an out patient basis provided detailed information about the hip joint and associated soft tissue. Results showed that SROM MRI was useful for planning of therapy.

### Introduction

The limitations of traditional imaging techniques, such as radiography<sup>4)5)10)</sup> or arthrography<sup>2)3)7)</sup>, have led many physicians treating childhood hip disease to look for alternatives. Due to its unsurpassed ability to reveal details of soft tissue, its lack of ionizing radiation, and

its non-invasive nature, MRI has for many practitioners become the imaging technique of choice<sup>1)8)9)11)12)</sup>.

### Materials and Methods

Around five years ago, we too needed to find a better imaging technique to guide us in treating Legg-Calve Perthes disease (LCPD). At

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Fig. 1.  
(A) AP and (B) frog leg lateral radiographs of the hip in a 9 year old girl with pillar C type LCP disease.



Fig. 2. Arthrograms taken at different positions of the hip : (A) neutral, (B) abduction, (C) abduction internal rotation, (D) abduction internal rotation flexion, and (E) adduction.

that time, 'dynamic arthrography,' or the use of arthrographs of the hip in 5 different positions (Fig. 1 and 2), was already being used to treat LCPD ; and for another disease-developmental dysplasia of the hip (DDH)-some workers were already using near real-time MRI, usually of the hip in the abduction-internal rotation-flexion position. We began to take MR images of the hip in 5 different positions (neutral, adduction, abduction, abduction internal rotation, and abduction internal rotation-flexion) of our LCP patients (Fig. 3). This approach was then extended to our patients suffering from DDH, and from avascular necrosis (AVN) of the hip ; and the data from these images have become the basis of our present research program. We have measured certain parameters from the images, and then performed statistical tests upon the measurements, enabling us to better understanding the diseases and their optimal treatment strategies. For some time we used to call our imaging approach 'dynamic MRI,' but since this term began to be already been used by some other workers to denote a different technique, we now refer to our method as Serial

Range of Motion MRI, or 'SRoM-MRI.'

Research such as this requires a real long-term commitment on the part of the investigators and their supporting institution(s). At Pusan National University Hospital (PNUH) the current cost for a normal full-body MR scan (including more than 100 T1, T2-weighted images) is 600,000 Korean won (close to 600 U. S. dollars at current exchange rates). As an inducement for the patients and their parents, PNUH has enabled us to offer a lower-cost SRoM-MRI comprised of only 3 slices in each of the 5 positions, of T2 weighted images only which is sufficient, for 330,000 won, of which one-quarter is subsidized by research funds of one of us (H. T. Kim) ; so that the patient pays only 250,000 won-meaning substantial savings over the original cost of 600,000 won. We of course explain to the patient and their family that the SRoM MRI can help them to understand the condition of the child's hip.

The younger children (and their parents or guardians) are brought into the MRI room, and the imaging is done within 30 minutes. Currently we use a machine whose bore measures 58

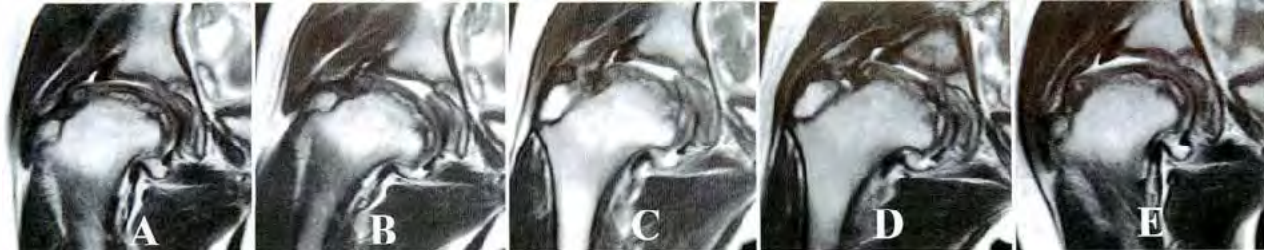


Fig. 3. SROM MRI taken at different positions of the hip : (A)neutral, (B)abduction, (C)abduction-internal rotation, (D)abduction internal rotation flexion, and (E) adduction.

cm. In the future we hope to use a larger machine that will allow greater abduction and accommodate older children. The long time frame involved in the healing process for LCPD means that this procedure must be repeated every 4 to 6 months beginning in the late AVN stage, through the fragmentation period and into the early re-ossification stage, amounting to a total period of about 1-1.5 years. At first, we used a foot holder to maintain the child's legs in each position, but this proved inconvenient. Currently, we find that older children often can maintain the positions unaided ; for younger patients, one of us simply holds the child's legs in the proper positions during scanning.

After the scanning is complete, we choose the best of the 3 slices in each position to use for analysis. For LCP disease, we proceed as follows. First, we note the position where congruency is maximized ; and then for each position we calculate the Epiphyseal Extrusion Index (EEI), the Head Coverage(IIC), and the Medial (Joint)Gap Ratio(MGR). We have so far made a total of 99 SROM MRIs of 78 LCP patients(6 female, 72 male ; average age 7.4 years ; 44 pillar B, 55 pillar C). For statistical comparison of parameter values between different positions, we use the paired t-test, with  $p$  values  $<0.05$  being considered statistically significant.

### Results

When moving from the neutral to the abduc-

tion position(Fig. 3 A-D), the parameters EEI and HC showed significant improvement in pillar B and pillar C patients. The MGR showed statistically significant improvement in the pillar B( $p<0.05$ ), but not in the pillar C patients. When moving from the neutral to the adduction position(Fig. 3 E), all 3 parameters indicated significant subluxation in the pillar C hips, although the more severely involved hips were actually more congruent in this position. In such cases, further subluxation was limited by soft tissue tension on the lateral and medial sides.

### Discussion

As we had hoped, SROM-MRI has proven to be useful in helping us to select a individualized therapy, whether it be simple range-of-motion exercise, a brace, or any pelvic and/or femoral osteotomy. Accordingly we have rejected the notion that a single type of osteotomy can be applied uniformly to all cases of a particular disease, as is customary at some clinics. We also believe that MR images of the hip in only one or two positions do not provide sufficient information for the physician to select the best possible treatment. However, we are not saying that MRI is always to be preferred over all other techniques ; we only mean that at the critical time when treatment is being decided upon, SROM-MRI has demonstrated certain advantages that should not be overlooked.

Implicit in all this is our belief that by basing our treatment decisions on SROM-MRI, we are

doing something better : that is, that our treatment for LCPD, DDH, and various types of AVN will ultimately result in fewer complications such as hip dysplasia, or result in simpler surgical procedures (or fewer unnecessary ones), and that patient satisfaction will, in general, be higher than if we had based our decisions upon some other type of imaging. As one example, in cases of LCPD with pillar C involvement, where the best congruency is found in the adduction position<sup>9)</sup>, we have discovered that a valgus osteotomy might be the preferred treatment; in such cases tension of the soft tissues around the joint may prevent further subluxation. Radiography alone could not have led to this conclusion<sup>4)5)10)</sup>.

We are aware that we bear a certain burden of proof here : that it is incumbent upon us, when sufficient data are available (i.e., when enough patients have passed through our doors and when sufficient time has elapsed), to put our results to the test—scientifically—which is to say, statistically.

In conclusion, SROM-MRI performed on an out-patient basis has provided more detailed information about the hip joint and associated soft tissue than radiographs or arthrographs; and was especially useful in the planning of therapy.

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