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*Published in:*  
Acta Radiologica

*DOI:*  
[10.1080/028418502127347808](https://doi.org/10.1080/028418502127347808)

2002

[Link to publication](#)

### *Citation for published version (APA):*

Laurell, L., Hochbergs, P., Rydholm, U., & Wingstrand, H. (2002). Capsular distance in the hip of the healthy child - normal values with sonography and MR imaging. *Acta Radiologica*, 43(2), 213-216.  
<https://doi.org/10.1080/028418502127347808>

*Total number of authors:*  
4

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## CAPSULAR DISTANCE IN THE HIP OF THE HEALTHY CHILD – NORMAL VALUES WITH SONOGRAPHY AND MR IMAGING

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### Abstract

*Purpose:* To determine the normal values of the anterior and posterior capsular distances of the hip joint in healthy children by means of US, using MR imaging as reference, and to evaluate any possible correlation between age, length, weight and anterior capsular distance (ACD).

*Material and Methods:* In our first study both hips in 14 healthy children (5–18 years old) were examined with US and MR to obtain measurements of the ACD and the posterior capsular distance (PCD). The distance from the anterior or posterior aspect of the femoral neck to the anterior or posterior aspect, respectively, of the outer limit of the capsule was determined. The distances were measured both with the hips in spontaneous external rotation of 10–15° and in internal rotation of 45°. In our second study, both hips in 28 healthy children (3–16 years old) were examined with US to determine the ACD. Age, length and weight were recorded.

*Results:* Study I: There was good correlation between the US and MR measurements in all positions. The ACD measured by US was significantly increased in inward rotation of the hip. Study II: There was no correlation between ACD and age, length or weight.

*Conclusion:* The PCD of the hip joint can be accurately measured by US with the hip in internal rotation of 45°. When compared with MR values, the ACD measured by US was dependent on the degree of rotation of the leg and increased significantly in internal rotation. Because the outer limit of the external layer of the joint capsule is sonographically more distinct, we suggest that the capsular distance should be measured from the outer limit of the joint capsule to the anterior or posterior aspect of the femoral neck. The measurement should be made perpendicular to the femoral neck, at the position where the greatest numerical value is obtained.

*Key words:* Hip, MR imaging; ultrasound; paediatric.

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*Accepted for publication 12 December 2001.*

In a patient with juvenile idiopathic arthritis (JIA) and clinical signs of hip synovitis confirmed by US, MR imaging revealed synovial proliferation and effusion, mainly located posteriorly (Fig. 1). This finding suggested that examination of the hip joint with US imaging of only the anterior aspect of the joint might not be sufficient when joint inflammation is suspected, and that was the starting point for the present studies.

The purpose of the studies was to establish a nor-

mal value for the posterior capsular distance (PCD) and to re-assess earlier findings of the anterior capsular distance (ACD) in healthy children using MR measurements as the gold standard, and to evaluate any possible correlation between age, length, weight and ACD.

### Material and Methods

The first study comprised 14 healthy children (9 girls and 5 boys; 28 hips) without any history of



Fig. 1. Oblique-sagittal MR view of the hip joint in a 17-year-old patient with JIA.

joint disease. One subject in each year span between the ages of 5 and 18 was included. There were four pairs of siblings among the subjects. US was performed ventrally in a plane along the axis of the neck of the femur (9) with a 7.5-MHz linear transducer (Aloka SSD-650 CL, Japan). Both hips of the children were examined in three different positions: i) supine with the hips in extension and spontaneous outward rotation of 10–15°; ii) supine with the hips in inward rotation of 45°; and iii) in a prone position with heels apart and the hips in inward rotation of 45°. US was performed from the dorsal aspect in the same plane as described above. US measurements were done by three independent examiners on the same occasion and the results were blinded between the observers. Each observer measured the ACD in the spontaneous external rotation twice.

For MR imaging, a Siemens Impact Expert 1.0 T unit was used. All children were examined in a body-array coil. T1-weighted spin-echo images (TR/TE 600/12 ms) were obtained in an oblique sagittal plane along the axis of the femoral neck with a slice thickness of 5 mm. A 512×512 reconstruction matrix was used with a field-of-view of 260–300 mm. The MR examinations were performed with the children supine with the hips in

extension and spontaneous external rotation of 10–15°, and with the hips internally rotated 45°. The ACD and PCD of the right hip were measured at a digital workstation.

The second study comprised 28 children (8 girls and 20 boys; 56 hips) with 2 subjects in each year span between the ages of 3 and 16, attending the clinic for various diseases and without any history of hip involvement. US was performed ventrally in the same plane as in the previous study (9) with a 10–5 MHz linear transducer (Sonosite 180, L38; Sonosite, USA). Both hips were examined in two different positions as described above under (i) and (ii). US measurements were done by the same experienced examiner and repeated twice. Weight and length were recorded by an experienced children's nurse.

## Results

*Study I:* The values for the ACD and PCD obtained with US and MR are graphically displayed in Fig. 2. There was no significant difference in the US and MR capsular distance of the right and left hips, nor was there any significant difference in the capsular distance at different ages or between the sexes. The mean ACD measured by US increased significantly ( $p=0.0001$ ) in inward rotation of the hip. A summary of all measurements is presented in the Table.

*Study II:* No correlation of ACD with age, length, or weight was found.

## Discussion

There are no previous reports of the normal sonographic capsular distance in the hip joint using MR values as a gold standard. Previous studies of the hip by US have focused on the evaluation of

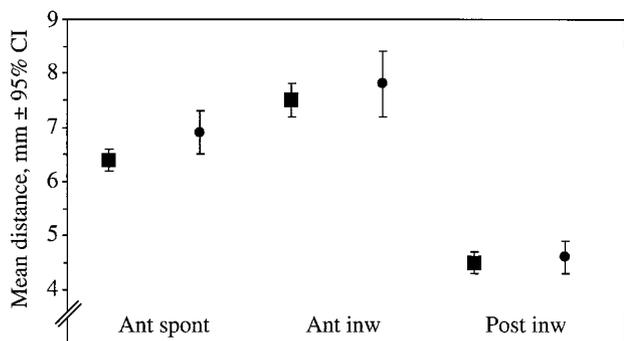


Fig. 2. Capsular distance in the hip of a healthy child. Mean values of the ACD and PCD measured by US ■ and MR ● in spontaneous outward rotation (spont) and 45° inward rotation (inw).

**Table**  
*Capsular distances in the hip of the healthy child in different positions of rotation*

	US				MR imaging			
	n	Mean distance, mm	SD	95% CI	n	Mean distance, mm	SD	95% CI
Anterior capsular distance								
spontaneous rotation	168	6.4	1.1	6.2–6.6	14	6.9	1.1	6.5–7.3
45° inward rotation	84	7.5*	1.4	7.2–7.8	14	7.8**	1.2	7.2–8.4
Post-capsular distance								
45° inward rotation	84	4.5	0.9	4.3–4.7	14	4.6	0.6	4.3–4.9

\*  $p=0.0001$ . \*\*  $p=0.02$ .

the anterior aspects of the joint (1, 3–8, 13), including children with unilateral symptoms using the asymptomatic hip as a reference (3, 5–7, 10) and hence not considering the possibility of asymptomatic synovitis (1). The exact position of the rotation of the hip was not always recorded. In this study we demonstrated the accuracy of the measurement of the PCD by US with the leg in 45° inward rotation. Because of the anatomical position of the femoral head (Fig. 3), the joint capsule cannot be visualized posteriorly by US with the leg in spontaneous external rotation, and thus the sonographic measurement of the PCD is only possible with the leg in inward rotation.

The MR finding of posterior synovial proliferation and effusion in the hip of one of our patients with JIA indicates that it may not be sufficient only to measure the ACD by US to exclude synovitis. Pre-operatively the structures of the anterior hip joint capsule seem relatively firm, with the leg in neutral position, in contrast to the greater laxity of the posterior one. This observation suggests that the convexity of the capsule, one of the son-

graphic criteria used in diagnosing synovitis, might be missed if the anterior approach is used exclusively.

Our results suggest that there is a significant increase of the ACD with the leg in inward rotation. This finding has been demonstrated earlier (8) and is in agreement with the finding of an increased intracapsular pressure when the hip is in extension that further increases when internal rotation is added (2, 12, 13). This observation is also in compliance with the clinical observation that patients with hip joint synovitis and increased intra-articular pressure prefer to keep the leg in a slightly flexed and moderately externally rotated position.

The present results suggest that both anterior

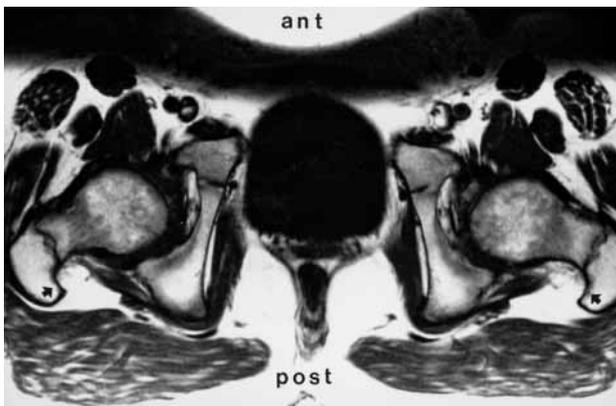


Fig. 3. Axial MR view of a hip joint in spontaneous external rotation. Inward rotation of the leg is necessary to uncover the femoral neck from the great trochanter (→) and thus make the US measurement of the PCD possible.

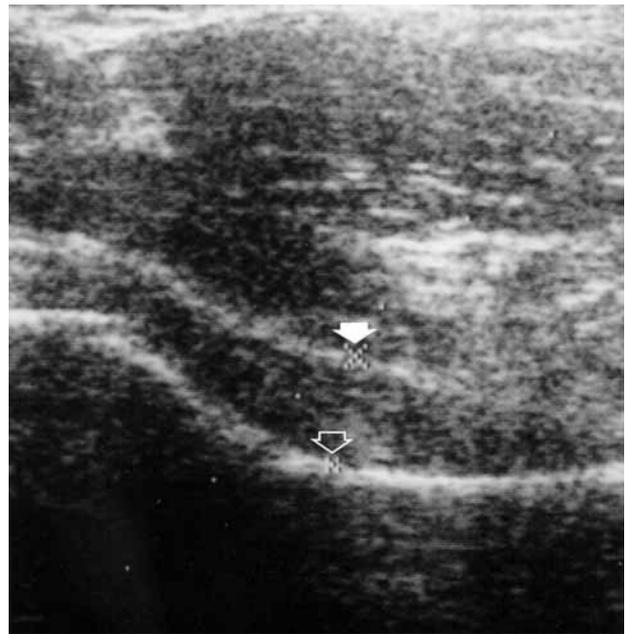


Fig. 4. Oblique-sagittal US image of the hip in a healthy child. The ACD is the maximum distance measured perpendicularly from the anterior surface of the femoral neck (⇔) to the outer limit of the external layer of the capsule (⇔) with the hip in extension and spontaneous outward rotation.

and posterior measurements of the capsular distance in various rotational positions may add valuable information, especially if there is a suspicion of synovitis in the hip. In patients with JIA, however, this might be difficult due to a restriction of movement caused by pain or fixed flexion deformities of the leg.

The anterior joint capsule comprises two fibrous layers lined by a synovial membrane (7, 8). In our study, we chose to measure the outer limit of the external layer (Fig. 4) since it is sonographically more distinct (a hyperechoic line representing the intersection between the iliopsoas muscle and the joint capsule) than the inner limit, which is attached to the synovial membrane. Several authors (3, 5, 6, 10) fail to specify whether the ACD measurements comprise the external or the internal limit of the external layer, which makes interpretation and comparison difficult.

In the first study, our measurements of the ACD by US and MR did not vary significantly with age. Previously published US reports have disagreed on this issue. There are studies reporting a correlation between age and ACD (10, 11) as well as studies reporting no such correlation (3, 7, 13). In our second study there was no correlation of ACD with age, length, or weight. Further studies need to address that subject.

*Conclusion:* Because the outer limit of the external layer of the joint capsule is sonographically more distinct, we suggest that in clinical practice the capsular distance should be measured from the outer limit of the joint capsule to the anterior or posterior aspect of the femoral neck. The measurement should be made perpendicular to the femoral neck, at the position where the greatest numerical value is achieved.

#### ACKNOWLEDGEMENTS

This work was funded by The Gyllenstiern Krapperrupp Foundation, King Gustaf V 80-year Foundation, Norrbacka Eugenia

Foundation, The Foundation for Aid to Disabled in Skåne, The Samaritan Foundation, The Sunnerdahl's Foundation for Disabled and The Sven Johansson's Memorial Foundation.

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