Coverage of the femoral head by the acetabular labrum in dysplastic hips

Quantitative analysis with radial MR imaging

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ABSTRACT **Hip dysplasia is an important cause of osteoarthrosis of the hip, especially in Japanese. Recently, the role of the acetabular labrum in hip diseases has attracted the attention of researchers, but the condition of the labrum in the dysplastic hips has not ben described. We used radial MRI to measure the degree of coverage of the femoral head by the acetabulum and the labrum, corresponding to 7 positions on the acetabular rim at every 15° from anterosuperior 45° via midsuperior to posterosuperior 45°. 38 Japanese patients (51 hips) with dysplasia, and 11 healthy controls (22 hips) were studied. In the dysplastic hips, the labrum was larger than in the controls. We found no correlation between the coverage of the acetabulum in the anterosuperior positions and the size of the labrum among the dysplastic hips.**

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Hip dysplasia is an important cause of osteoarthrosis of the hip, especially in Japanese (Takaoka et al. 1988). The center-edge (CE) angle (Wiberg 1953) and Sharp's angle (Sharp 1961) have been used as radiographic indices of the degree of hip dysplasia. Their relation to onset and progression of osteoarthrosis has been studied in detail (Lloyd-Roberts 1955, Cooperman et al. 1983). Recently, the role of the acetabular labrum in hip diseases has attracted attention (Harris et al. 1979, Dorrell and Catterall 1986, Klaue et al. 1991, Czerny et al. 1996), not least because the labrum can be clearly seen with MRI (Hodler et al. 1995, Czerny et al. 1996, Kubo et al. 1999, 2000). Some authors have reorted changes in and at the site of attachment of the labrum in osteoarthrosis (Horii et al. 2000) and a larger cross-sectional area in the dysplastic hip than in the healthy hip (Kubo et al. 2000a). The labrum forms a ring around the acetabular margin, and a radial MRI setting (Kubo et al. 1999) permits visualization of an extensive cross-section of the labrum at one time.

We used radial MRI to measure the degree of acetabular and labral coverage of the femoral head to evaluate the following hypotheses: (i) the dysplastic hip may have a greater degree of labral coverage of the femoral head, (ii) the degree of labral coverage may not correlate with the degree of dysplasia, and (iii) the pattern of labral and acetabular coverage in relation to the position may differ in dysplastic and healthy hips.

Patients and methods

We studied 51 hip joints in 38 Japanese patients (all females) who were examined in our hospital between January 1995 and December 1999. All of them had hip dysplasia, defined as an acetabulum with a Sharp's angle of 45° or more, and no radiographic signs of osteoarthrosis, such as joint space narrowing or sclerosis of the femoral head or acetabulum. Only 17 patients (17 hips) had symptoms—i.e, intermittent hip pain on walking. The others had various problems in the contralateral hip related to dysplasia (dysplasia with pain (13), osteoarthrosis (16), previous pelvic osteotomy (5 hips).

Patients with a congenital hip dislocation or those who had a history of hip disorders other than dysplasia were not included. Those who received surgical treatment or a brace due to dysplasia were also excluded. In addition, patients with a dislocation and/or severe contracture of the contralateral hip joint were excluded to avoid tilting of the pelvis during MR imaging. Severe contracture was defined as any one of the following conditions: flexion < 40°, abduction < 40°, adduction < 15°, extension < 10°, internal rotation < 0°, and/or external rotation < 30°.

The mean age of the patients was 27 (15–52) years. There were 28 right and 23 left hips. Sharp's angle was mean 48 (45–57)° and the CE angle was mean 19 (-4 to 27)°. None of the patients had had an arthroplasty on the opposite hip.

The 11 controls had no abnormal findings on plain radiographs. Their mean age was 26 (21–36) years. Both hips were examined. Sharp's angle was mean 41 (36–42)° and the CE angle mean 33 (27–45)°. The aim of our study was explained to all subjects and their written informed consent was obtained. It was approved by the Ethics Committee for the Study of Human Subjects in Kyoto Prefectural University of Medicine.

A 1.0 or 1.5 tesla MR superconductor (Shimadzu, Kyoto, Japan) was used. T2*-weighted images were obtained with the STAGE method (TR: 500 msec, TE: 20 msec, flip angle: 30°) (Elster 1993, Horii et al. 1997), a type of gradient echo (GRE) method and using a local surface coil. No noticeable differences were detected between the images obtained by the 1.0 and 1.5 tesla MR devices. During radial MRI, the subjects were placed on the table in a standardized supine position.

To determine imaging sections, a scout view including the full circumference of the acetabular margin was taken after correction for acetabular anteversion and the angle of acetabular inclination (Horii et al. 2000). 12 radial sections (section thickness 4 mm) were set at 15° intervals on the geometrical center of the acetabulum in the scout view (Figure 1).

Each radial MRI section comprised 2 positions on the acetabular margin. The coverage of the femoral head with the acetabulum and labrum was measured on 7 positions from the superior quarter of the acetabulum. These positions were the mid-

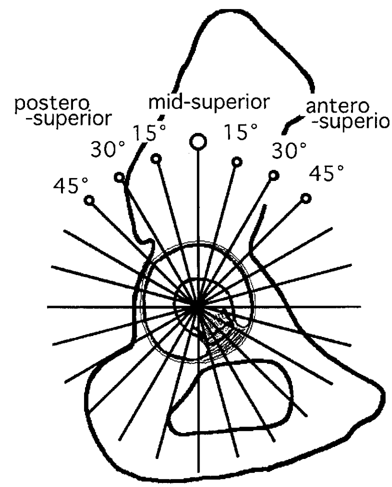


Figure 1. Positions of the 12 radial sections.

superior; anterosuperior 15°, 30° and 45°; and posterosuperior 15°, 30° and 45°. In the coverage measurements (Figure 2), the center of the femoral head was first found using concentric circles on a transparent sheet. 3 lines were drawn:(i) a first line through the center of the femoral head, which crossed the acetabular margin perpendicularly, (ii) a second line connecting the center of the femoral head with the outer margin of the acetabulum (line a in Figure 2) and (iii) a third line connecting the center of the femoral head with the outer margin of the labrum (line b in Figure 2). The angle formed by the perpendicular line and 'line a' shows the acetabular covering angle (AC angle), the angle formed by the perpendicular line and 'line b' shows the total covering angle (TC angle), and the angle formed by 'lines a and b' shows the labral covering angle (LC angle). In each position, these 3 angles were compared between the dysplastic hips and the healthy controls. The correlation coefficients of the AC and LC angles at each position were also examined.

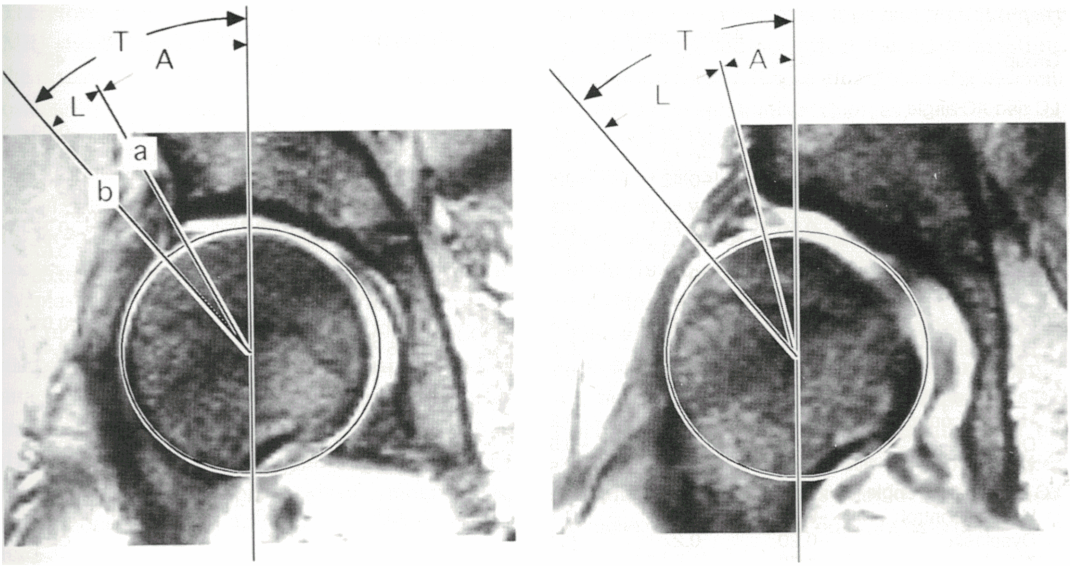
On radial MR images, the vertical direction (y-axis) shows the intersection of a plane with the sagittal plane. Therefore, in the midsuperior position, the AC and TC angles show the inclination from the cephalocaudal line.

Statistical analysis was performed by using Mann-Whitney's U-test for intergroup comparisons and Spearman's rank correlation for the correlation coefficients, using Stat View 4.0 J for Macintosh (Abacus Concepts, Inc., Berkeley).

Figure 2. Method of measuring the degree of coverage.

a. Normal volunteer.

b. Dysplastic hip.



At first, the center of the femoral head was found using concentric circles on a transparent sheet. Then, 3 lines were drawn: one through the center of the femoral head, which crosses vertically to the acetabular margin, another connecting the center of the femoral head with the outer margin of the acetabulum (line a), and a third connecting the center of the femoral head with the outer margin of the labrum (line b). The angle formed by the vertical line and line a was called the acetabular covering angle (AC angle), the angle formed by the vertical line and line b was named the total covering angle (TC angle), and the angle formed by lines a and b was named the labral covering angle (LC angle).

Table 1. Median and range of the AC, TC and LC angles in each position. Values are median (range)

	Anterosuperior			Midsuperior	Posterosuperior		
Group	45°	30°	15°		15°	30°	45°
AC angle							
Healthy control	40 (30–55)	35 (28–52)	34 (26–47)	32 (26–44)	30 (24–45)	27 (20–43)	33 (27–47)
Dysplasia	36 (18–50)	30 (6–52)	24 (–1–40)	20 (–2–39)	20 (–2–33)	18 (–4–32)	23 (–4–40)
TC angle							
Healthy control	50 (40–64)	44 (36–62)	44 (39–56)	40 (37–53)	44 (28–55)	44 (38–55)	47 (40–60)
Dysplasia	48 (24–74)	44 (18–66)	39 (20–60)	38 (20–54)	40 (18–58)	40 (20–54)	46 (20–58)
LC angle							
Healthy control	9 (0–22)	8 (2–13)	9 (2–14)	10 (5–12)	13 (9–20)	17 (9–26)	15 (11–21)
Dysplasia	12 (0–30)	12 (5–22)	16 (4–24)	19 (6–30)	22 (2–32)	24 (12–33)	22 (12–40)

Results

The AC angle was smaller at every position in the dysplastic hips than in the controls ($p < 0.01$; Table 1). The TC angle was smaller in the dysplastic hips than in the healthy controls in the anterosuperior 15° and posterosuperior 15° positions ($p < 0.05$; Table 1).

The LC angle was greater at every position in the dysplastic hips than in the healthy controls ($p < 0.01$; Table 1). The correlation coefficient of the CE angle and midsuperior AC angle was 0.74 in the dysplastic hips and 0.86 in the healthy controls ($p < 0.001$).

We found a negative correlation between the LC and AC angles in the dysplastic hips from the anterosuperior 15° to the posterosuperior positions, but the absolute values of the correlation coefficients were small (Table 2). The TC angle correlated with the AC angle, especially in the

Table 2. Correlation coefficients (Spearman's rank correlation) of the LC and AC, TC and AC, AC and Sharp's, TC and Sharp's, LC and Sharp's angles

Group	Anterosuperior 45°	Anterosuperior 30°	Anterosuperior 15°	Midsuperior	Posterosuperior 15°	Posterosuperior 30°	Posterosuperior 45°
LC and AC angle							
Healthy control	–0.42	–0.59 [b]	–0.68 [b]	–0.45 [a]	–0.58 [b]	–0.68 [b]	–0.09
Dysplasia	–0.02	–0.18	–0.38 [b]	–0.50 [c]	–0.51 [c]	–0.44 [b]	–0.43 [b]
Total	–0.23	–0.42 [c]	–0.62 [d]	–0.75 [d]	–0.72 [d]	–0.66 [d]	–0.64 [d]
TC and AC angle							
Healthy control	0.56 [a]	0.78 [c]	0.56 [a]	0.77 [c]	0.58 [b]	0.50 [a]	0.74 [c]
Dysplasia	0.80 [d]	0.78 [d]	0.79 [d]	0.76 [d]	0.66 [d]	0.76 [d]	0.67 [d]
Total	0.74 [d]	0.70 [d]	0.77 [d]	0.69 [d]	0.67 [d]	0.68 [d]	0.63 [d]
AC and Sharp's angle							
Healthy control	–0.12	–0.52 [a]	–0.39	–0.40	–0.29	–0.06	–0.01
Dysplasia	–0.31 [a]	–0.50 [c]	–0.52 [c]	–0.46 [b]	–0.49 [c]	–0.43 [b]	–0.43 [b]
Total	–0.41 [c]	–0.61 [d]	–0.71 [d]	–0.74 [d]	–0.75 [d]	–0.67 [d]	–0.65 [d]
TC and Sharp's angle							
Healthy control	–0.30	–0.41	–0.23	–0.34	0.04	–0.25	–0.25
Dysplasia	–0.35 [a]	–0.36 [a]	–0.56 [d]	–0.51 [c]	–0.57 [d]	–0.55 [c]	–0.24
Total	–0.28 [a]	–0.25 [a]	–0.57 [d]	–0.44 [c]	–0.51 [d]	–0.48 [d]	–0.27 [a]
LC and Sharp's angle							
Healthy control	–0.15	0.10	0.16	0.43 [a]	0.30	–0.14	0.21
Dysplasia	–0.20	0.27	0.12	0.16	0.12	0.14	0.25
Total	0.20	0.58 [d]	0.54 [d]	0.67 [d]	0.57 [d]	0.51 [d]	0.58 [d]

[a] $p < 0.05$
[b] $p < 0.01$
[c] $p < 0.001$
[d] $p < 0.0001$

dysplastic hips (Table 2).

Sharp's angle correlated with the AC and TC angles, but not with the LC angle in the dysplastic hips (Table 2). The correlation coefficients between the Sharp's and CE angles were –0.54 ($p < 0.001$) in the dysplastic hips, –0.43 ($p = 0.05$) in the healthy controls, and –0.83 ($p < 0.001$) in total.

Discussion

The anatomy of the labrum in adult dysplastic hips has not yet been clarified (Kubo et al. 2000a), although ultrasound can show its major abnormalities in infants with congenital dislocation of the hip. Therefore, quantitative examination of labral coverage would be useful to clarify the relationship between the shape of the labrum and hip joint diseases.

With MRI, the relationships between the labrum, bony acetabulum, and the femoral head can be visualized (Hodler et al. 1995, Czerny et al. 1996, Kubo et al. 1999, 2000a). The present study obtained T2*-weighted images using the GRE method, and in these images, the center of the femoral head is easily determined because the articular cartilage is clearly seen as a high intensity region. In the boundary between the bone and labrum, high intensity regions were found to be adjacent to the cartilage (Hodler et al. 1995, Kubo et al. 1999). Therefore, the coverage of the femoral head by the acetabulum and labrum can be measured easily with the same procedure used to measure the CE angle on plain radiographs. The radial setting can show a wide range of labral coverage, which permits determination of the characteristics of labral coverage in various locations.

Our findings showed that the LC angle was larger in the dysplastic hips than in the healthy controls in all positions—i.e., the labral coverage was greater in the dysplastic hips. The larger labrum would replace the insufficient acetabular coverage, and morphologically, the labrum in dysplastic hips would be subjected to a heavier load. In the previous study (Horii et al. 2000), abnormalities were frequently detected on the labrum and its acetabular attachment in hips with moderate osteoarthrosis. In dysplastic hips, osteoarthritis becomes worse when the labrum has collapsed. Therefore, monitoring of the labrum using radial MRI should be useful in predicting worsening of the disease or in selecting methods of treatment in osteoarthritis patients.

In the anterosuperior position of dysplastic hips, the AC and LC angles showed no correlation. This finding indicates that the labrum was not necessarily large in patients with a small bony acetabular coverage. It has been reported that the labrum in dysplastic hips is easily torn in the anterosuperior part of the acetabulum (Pitto et al. 1996). MRI has also shown that abnormalities of the labrum and its attachment are most frequently found in this position in osteoarthritis (Horii et al. 2000). Individual differences in the femoral head coverage may be related to the onset and prognosis of osteoarthrosis. If so, radial MRI may become an important diagnostic tool in the future.

The characteristics of coverage in each position of the labrum and acetabulum were similar in both the dysplastic hips and healthy controls—i.e., the LC angle (labral coverage) was largest and the AC angle (acetabular coverage) was smallest in the posterosuperior 30° position in both groups. However, the group difference in the AC angle was larger in the midsuperior and posterosuperior positions than in the anterosuperior ones. This is because the acetabular anteversion in dysplastic hips is smaller than in normal hips. The difference in the LC angle was larger in the midsuperior and posterosuperior positions than in the anterosuperior ones, which suggested that the labrum forms to supplement the inadequacy of anteversion.

With MRI, one has to examine the right and left hips separately to obtain a good image of the labrum. Therefore, it is impossible to determine the inclination of the pelvis from the images themselves, and it is important to ensure that there is no inclination of the pelvis during imaging. In the present study, we paid particular attention to this point. Patients with an obvious contracture of the opposite hip joint were excluded from the study if there appeared to be an inclination of the pelvis during imaging.

Labral pathology shows abnormal signal intensity on MRI. In dysplastic hips without osteoarthrosis on plain radiographs, high intensity areas are seen more frequently (and more obviously) than in healthy hips (Kubo et al. 2000a). In fact, many of our subjects' hips had high intensity areas, but they did not affect the angle measurements in this study. These changes in signal intensity represent qualitative changes, such as tissue degeneration (Kubo et al. 2000b). They show no relation to the size of the diseased/damaged area, and therefore we did not try to eliminate this factor. Moreover, none of our subjects had even a slight labrum rim or rupture of the labrum on its attachment (Horii et al. 2000).

Our subjects were all Japanese females. Dysplasia is an important cause of osteoarthrosis of the hip, but it does not occur only in Japanese. Hip dysplasia is frequently seen in females, and the cause of the gender difference has not yet been determined. Future studies should focus on non-Japanese populations and on male patients.

MRI permitted clearly visible and extensive observations of the spatial relations between the labrum, acetabulum, and femoral head. Measurements of the AC, LC and TC angles on radial MR images are easily performed, and these angles could be used as an anatomical index of dysplasia because coverage by the labrum and acetabulum can be evaluated in the desired positions. Harris et al. pointed out the possible abnormality of the labrum in primary osteoarthrosis of the hip (Harris et al. 1979). If radial MRI is used in the examinations for primary osteoarthritis of the hip, certain labral abnormalities could also be detected.

In conclusion, (i) dysplastic hips have a larger coverage of the femoral head with the labrum, (ii) the degree of labral coverage does not necessarily correlate with the degree of dysplasia, and (iii) the characteristics of coverage in each position of the labrum and acetabulum were similar in both the dysplastic hips and healthy controls.

No competing interests declared.

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