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Relationship of acetabular dysplasia in females with osteoarthritis of the hip to the distance between both anterior superior iliac spines

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Background: Acetabular dysplasia (AD) is the main cause of hip osteoarthritis in Japan. A simple method to evaluate acetabular dysplasia would be helpful for early treatment or prevention of hip osteoarthritis. Acetabular dysplasia is reported to be associated with pathological transverse growth of the pelvis, indicating that the distance between the 2 anterior superior iliac spines might be useful for screening and detection of acetabular dysplasia. The purpose of this study was to determine if the acetabular dysplasia radiographic parameters are related to the distance between the 2 anterior superior iliac spines in patients with hip osteoarthritis.

Material/Methods: In this study, data obtained in a previous multi-institutional examination of patients with hip osteoarthritis in Japan were evaluated. The anterior superior iliac spine distances of 176 female patients (mean age, 54 years; range, 18-85 years) were measured by physical examination. The relationship between the anterior superior iliac spine distance and acetabular dysplasia was analyzed, and the anterior superior iliac spine distances of the patients with acetabular dysplasia who were at relatively high risk for hip osteoarthritis were compared with that of the patients at lower risk.

Results: A statistically significant relationship between the anterior superior iliac spine distance and all of the acetabular dysplasia parameters was observed. The anterior superior iliac spine distances of the acetabular dysplasia patients with a relatively high risk for radiographic acetabular dysplasia parameters were significantly smaller than those of patients at lower risk. Even after adjustment for age, height, and weight, significantly increased relative risk for having high risk AD was found in patients with an ASIS distance of less than 24.5 cm.

Conclusions: There was a significant relationship between the anterior superior iliac spine distance and the degree of acetabular dysplasia.

MeSH Keywords: **Pelvic Bones • Acetabular dysplasia • Anterior superior iliac spine • Bone Diseases, Developmental • Osteoarthritis, Hip**

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Background

A recent nationwide epidemiological study on osteoarthritis (OA) of the hip in Japan showed that 59% of hip OA patients admitted to the orthopedic outpatient clinic had progressed to an advanced or terminal stage [1,2]. Even in younger patients, such as those in their 40s, 45% had severe hip OA [2]. Most of these patients will need total hip arthroplasty in the near future. With early detection, other treatment options, such as osteotomy, would be available for patients with severe hip OA. Many reports have shown good clinical outcomes of the periacetabular osteotomy for hip OA at an early stage [3–6] and those with a partial degree of a pre-advanced stage [7–11].

Japanese patients with OA have been reported to have higher rates of dysplasia than American patients [12], and significantly worse dysplasia than that in British populations [13]. A previous epidemiological study in Japan showed that approximately 80% of hip OA occurrences were secondary to acetabular dysplasia (AD) [11]. These data suggest that it is possible to identify hip OA before it progresses to an advanced or terminal stage by detecting AD. Although radiography of the pelvis is a good technique for the estimation of AD, it is not appropriate for screening large populations. A simpler evaluation tool is necessary.

Based on computerized tomography (CT), patients with AD have been reported to have a reduced transverse diameter of the pelvic inlet [14]. A hypoplastic inward wing of the ileum is a feature in AD patients that can be observed on X-ray radiography [15].

The anterior superior iliac spine is a well-known palpable bony landmark of the ileum that has been used to estimate the spina-malleolar distance as the leg length or the range of hip motion on clinical examination of hip joints. Measurement of the distance between the 2 anterior superior iliac spines (ASIS distance) is a simple method for estimation of pelvis size. The question of whether the ASIS distance is useful for screening and detection of AD without the use of radiographs has not been addressed. The relationship between clinical measurement of the ASIS distance and any of the radiographic parameters for AD in patients with hip OA was investigated in this study.

Material and Methods

In this study, data obtained in a previous multi-institutional examination of patients with hip OA in Japan were evaluated [1, 2]. Data were collected prospectively from patients who were newly admitted to the orthopedic outpatient clinic of each institution. Eleven institutions in 5 areas of Japan participated in this study. Patients were limited to those old enough to

have hip joints with a completed closure of the growth plate. Patients were excluded if they had undergone an operation on both hip joints after the growth plate closure. Hip OA was defined as a symptomatic hip joint that had radiological evidence of OA changes. Symptomatic hip joints with a deformity in the joint, such as acetabular dysplasia or dislocation, but no OA changes were also included. Data were collected for 9 months after the study had received approval from the institutional review boards of the abovementioned institutions, including that of the first author's institution. Written informed consent was obtained from each patient.

All radiographs were performed with subjects in the supine position. Anteroposterior radiographs were taken with a source-to-film distance of 110 cm. The patient's feet were internally rotated with the toes at $15\pm 5^\circ$ to ensure that the X-ray beam was centered on the superior aspect of the pubic symphysis.

The stage of hip OA was classified according to the guidelines proposed by the Japanese Orthopaedic Association's committee [16] on evaluation criteria for this condition. These classifications were revised according to the reproducibility in the previous preliminary study [17] to ensure reliable data from multiple institutions. OA of the hip was classified into 1 of 4 stages: stage 1 (pre-arthritis), no osteoarthritic change; stage 2 (initial stage), 1 or more arthritic changes with possible narrowing of the joint space, the width of joint space is maintained as 2 mm or more throughout the weight-bearing area; stage 3 (advanced stage), definite narrowing of joint space, the width is less than 2 mm at the thinnest point, loss of joint space is observed, and the width is less than 15 mm; and stage 4 (terminal stage), gross loss of joint space, the width is 15 mm or more. Because of the difficulty in measurement due to severe OA deformity, joints at the stage 4 (terminal stage) were excluded. There were 85 patients in stage 1, 28 in stage 2, and 63 in stage 3.

AD indices were also chosen according to the reproducibility of the multi-institutional examinations [17] for the Sharp angle [18], center-edge angle [19], acetabular roof obliquity angle [20], acetabular head index (AHI), and approximate acetabular quotient [21]. The Sharp angle, acetabular roof obliquity angle, and AHI were assessed to be reproducible indices and measured in an anteroposterior view radiograph of the bilateral hip joints (Figure 1).

The ASIS distance of patients was measured (Figure 2) and compared with each AD index. When bilateral hip joints were measured in a patient, the joint with the higher degree of AD was chosen for further analysis. To exclude the effect of sex on the pelvic size, we excluded 32 male patients from the study. In this study, 176 female patients (mean age, 54.1 years; range, 18–85) were examined.

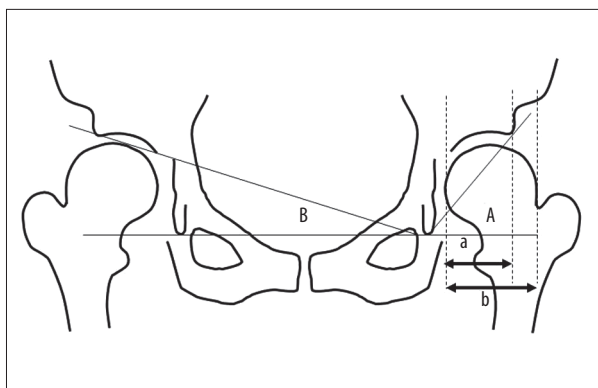


Figure 1. Radiographic parameters of acetabular dysplasia (AD). A – Sharp angle; B – acetabular roof obliquity angle; AHI – acetabular head index = $a/b \times 100$.



Figure 2. Right and left anterior superior iliac spine (ASIS) was arrowed on the pelvic model. ASIS distance was defined as the distance in a straight line between right and left anterior superior iliac spine (dotted line).

Measurement of ASIS distance and radiographic parameters were measured by an experienced orthopedic surgeon at each institution. To test the reproducibility of the measurements, 3 orthopedic surgeons (K.O., K.Y., and Y.N.) measured the ASIS distance of 12 randomly selected patients. Each observer measured each hip 2 times, with an interval of 1 day between measurements, and the values were averaged. The data were analyzed for intra-observer and inter-observer variances, and the coefficient of variation was calculated to be <5%. The reproducibility of the measurements was therefore considered reasonable.

The patients were divided into 2 groups depending on the degree of each AD parameter of the hip joint, and the differences in the ASIS distance between the 2 groups were examined. The patients with parameters that gave more than a 5-fold higher relative risk for hip OA (relative to the other patients), according to the previous data in the same series [2], were placed in

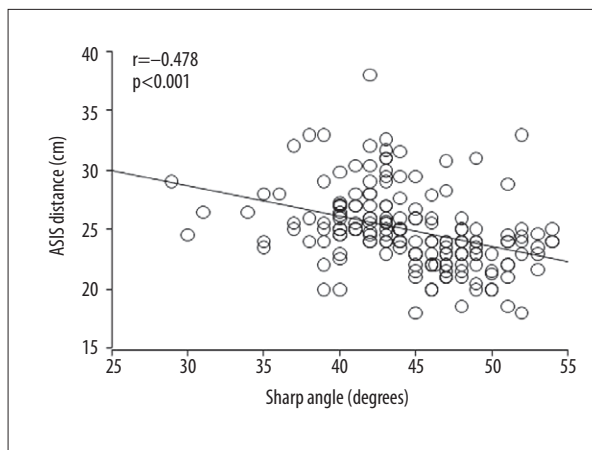


Figure 3. The relationship between the anterior superior iliac spine (ASIS) distance and the Sharp angle.

the high-risk AD group. Each patient in the high-risk AD group had more than a 45° Sharp angle, more than a 20° acetabular roof obliquity angle, or less than 70% AHI.

For analysis of the relative risk based on the ASIS distance for high-risk AD, patients were divided into the following quartiles according to the distribution of ASIS distance for the entire study subjects, with the category boundaries drawn so as to make the size of groups as similar as possible: Q1 (<23 cm ASIS distance), Q2 (23.0–24.4 cm), Q3 (24.5–26.4 cm), and Q4 (>26.5 cm). The relative risk was calculated as the odds ratio against group Q4 by using logistic regression models. The 95% confidence interval was also calculated. In addition, association between the ratio of ASIS distance to height and high-risk AD was analyzed in a similar manner.

The Wilcoxon rank sum test was used to assess the differences in each characteristic between the 2 groups. Spearman's correlation coefficient was used to determine correlations between the ASIS distance and the Sharp angle, acetabular roof obliquity angle, and AHI. All analyses were performed using the Statistical Analysis System version 9.1 software program package (SAS Institute, Cary, NC). Differences with $p < 0.05$ were considered to be statistically significant.

Results

The mean ASIS distance was 25.0 cm (range, 18.0–38.0). The mean Sharp angle, acetabular roof obliquity angle, and AHI were 44.5° (range, 29–54), 18.5° (range, -4–47), and 72.5% (range, 38.5–100), respectively. There were statistically significant relationships between the ASIS distance and all of the AD parameters. The Sharp angle significantly increased with decreasing ASIS distance (Figure 3). There were also correlations between the ASIS distance and acetabular roof obliquity

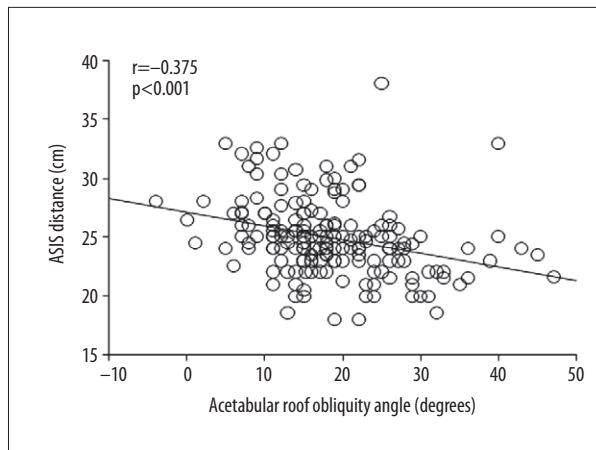


Figure 4. The relationship between the anterior superior iliac spine (ASIS) distance and the acetabular roof obliquity angle.

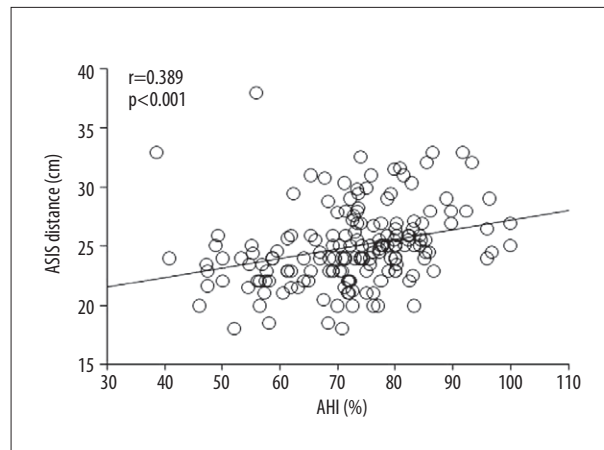


Figure 5. The relationship between the anterior superior iliac spine (ASIS) distance and the acetabular head index (AHI).

Table 1. Comparison of age, height, weight, body mass index, anterior superior iliac spine (ASIS) distance and ratio of ASIS distance to height between patients with or without relatively high-risk AD.

	Total subjects (n=176)	Sharp angle		p*	Acetabular roof obliquity angle		p*	AHI		p*
		≥45 (n=86)	<45 (n=90)		≥20 (n=67)	<20 (n=109)		<70 (n=58)	≥70 (n=118)	
ASISD	25.0±3.3 (18–38)	23.3±2.7 (18–33)	26.5±3.0 (20–38)	<0.001	24.0±3.4 (18–38)	25.5±3.1 (18–33)	<0.001	23.9±3.4 (18–38)	25.5±3.1 (18–33)	<0.001
Age (years)	54.1±15.0 (18–85)	47.5±13.8 (18–79)	60.4±13.4 (24–85)	<0.001	53.2±14.4 (18–78)	54.7±15.4 (23–85)	0.507	50.6±13.3 (21–79)	55.8±15.6 (18–85)	0.013
Height (cm)	154.5±6.0 (135–171)	155.4±6.0 (141–171)	153.6±5.9 (135–168)	0.029	153.3±6.4 (135–165)	155.2±5.6 (144–171)	0.199	154.6±5.5 (141.8–170)	154.4±6.2 (135–171)	0.901
Weight (kg)	55.8±9.3 (35–88)	54.0±8.7 (39–83)	57.5±9.5 (35–88)	0.006	54.8±10.2 (35–88)	56.4±8.6 (39–83)	0.196	55.1±9.7 (40–88)	56.1±9.1 (35–78)	0.235
Body mass index (kg/m ²)	23.3±3.8 (17.1–38.1)	22.4±3.3 (17.1–32.9)	24.4±4.0 (17.1–38.1)	<0.001	23.3±4.0 (17.1–38.1)	23.5±3.6 (17.1–36.1)	0.606	23.1±3.8 (17.1–38.1)	23.6±3.8 (17.1–36.1)	0.270
Ratio of ASISD to height	0.160±0.020 (0.116–0.260)	0.150±0.017 (0.116–0.217)	0.173±0.019 (0.146–0.260)	<0.001	0.157±0.023 (0.116–0.260)	0.165±0.020 (0.117–0.224)	0.003	0.155±0.023 (0.116–0.260)	0.165±0.020 (0.121–0.224)	<0.001

Data expressed as means ± SD (range); *Wilcoxon rank sum test.

angle (Figure 4) and AHI (Figure 5); the degree of AD increased with decreasing ASIS distance for these parameters. The same trend was observed using the ratio of ASIS distance to height (Sharp angle: $r = -0.523$, $P < 0.001$, acetabular roof obliquity angle: $r = -0.308$, $P < 0.001$, AHI: $r = 0.369$, $P < 0.001$).

The ASIS distance with Sharp angles in patients who had a relatively high risk for hip OA was significantly smaller than that in low-risk patients (Table 1), while the height was greater in

patients with high-risk AD than that in lower-risk patients. The ASIS distance of patients with high-risk AD was also smaller than that of lower-risk patients, depending on the degree of the acetabular roof obliquity angle or AHI. There was no difference in the height for either parameter between the 2 groups.

The relative risk of the ASIS distance for high-risk AD was determined after adjustment for age, height and weight (Table 2). Compared with the ASIS distance of 26.5 cm or more, smaller ASIS

Table 2. The relative risk of the anterior superior iliac spine (ASIS) distance for high-risk acetabular dysplasia (AD).

Outcome indicator		ASISD				Trend p
		Q1	Q2	Q3	Q4	
		<23.0 cm	23.0–24.4 cm	24.5–26.4 cm	≥26.5 cm	
Sharp angle (≥45°)	n/N (%)	33/37 (89)	33/47 (70)	12/46 (26)	8/46 (17)	
	OR (95%CI)*	71.6 (14.1–362.9)	16.2 (4.89–53.7)	2.25 (0.71–7.07)	1.00 (reference)	<0.001
	P value	<0.001	<0.001	0.167		
Acetabular roof obliquity angle (≥20°)	n/N (%)	22/37 (59)	21/47 (45)	15/46 (33)	9/46 (20)	
	OR (95%CI)*	5.64 (1.94–16.4)	3.26 (1.23–8.61)	1.88 (0.72–4.94)	1.00 (reference)	<0.001
	P value	0.002	0.017	0.200		
AHI (<70°)	n/N (%)	19/37 (51)	22/47 (47)	11/46 (24)	6/46 (13)	
	OR (95%CI)*	7.27 (2.28–23.2)	6.06 (2.08–17.7)	2.14 (0.71–6.47)	1.00 (reference)	<0.001
	P value	<0.001	0.001	0.176		

* Adjusted for age, height, weight (continuous variables). AHI – acetabular head index.

Table 3. The association between ratio of anterior superior iliac spine (ASIS) distance to height and the high-risk acetabular dysplasia (AD).

Outcome indicator		Ratio of ASISD to height				Trend p
		Q1	Q2	Q3	Q4	
		<0.149	0.149-0.159	0.160-0.171	>0.171	
Sharp angle (≥45°)	n/N (%)	41/45 (91)	24/40 (60)	15/47 (32)	6/44 (14)	
	OR (95%CI)*	49.3 (11.6–208.7)	9.65 (3.00–31.0)	3.66 (1.16–11.5)	1.00 (reference)	<0.001
	P value	<0.001	<0.001	0.027		
Acetabular roof obliquity angle (≥20°)	n/N (%)	25/45 (56)	17/40 (43)	16/47 (34)	9/44 (20)	
	OR (95%CI)*	5.18 (1.86–14.4)	2.93 (1.09–7.85)	1.99 (0.77–5.17)	1.00 (reference)	0.001
	P value	0.002	0.033	0.156		
AHI (<70°)	n/N (%)	24/45 (53)	17/40 (43)	10/47 (21)	7/44 (16)	
	OR (95%CI)*	5.72 (1.96–16.7)	3.92 (1.38–11.1)	1.47 (0.50–4.29)	1.00 (reference)	<0.001
	P value	0.001	0.010	0.484		

* Adjusted for age, weight (continuous variables). AHI – acetabular head index.

distances revealed higher ORs for high-risk AD. For Sharp angle (≥45), ASIS distance of 23.0–24.4 cm and of less than 23.0 showed 16- and 72-fold greater ORs with statistically significant levels. In addition, these associations were observed for acetabular roof obliquity angle or AHI. For acetabular roof obliquity angle (≥20), these ORs (P value) were 3.26 (P=0.017) and 5.64 (P=0.002), respectively. For AHI (<70), corresponding ORs were 6.06 (P=0.001) and 7.27 (P<0.001). Based on the association with every AD parameter, there was a significantly dose-responder relationship toward smaller ASIS distance for high-risk AD. The same trend was observed using the ratio of ASIS distance to height (Table 3).

The relative risk of the ASIS distance for relatively high-risk AD was determined using any of the AD parameters. On the

basis of these results, the cutoff value of the ASIS distance for screening patients with a relatively high risk of hip OA could be determined. In the Q2 and Q1 groups, significantly increased relative risks were obtained by using all of the parameters. For a cutoff value of 24.5 cm, 66 of 84 subjects (79%) had Sharp angles of more than 45°, 43 (51%) had acetabular roof oblique angles of more than 20°, and 41 (49%) had AHI of less than 70%.

Discussion

The degree of AD increased with decreasing ASIS distance for all of the AD parameters, each of which correlated with the

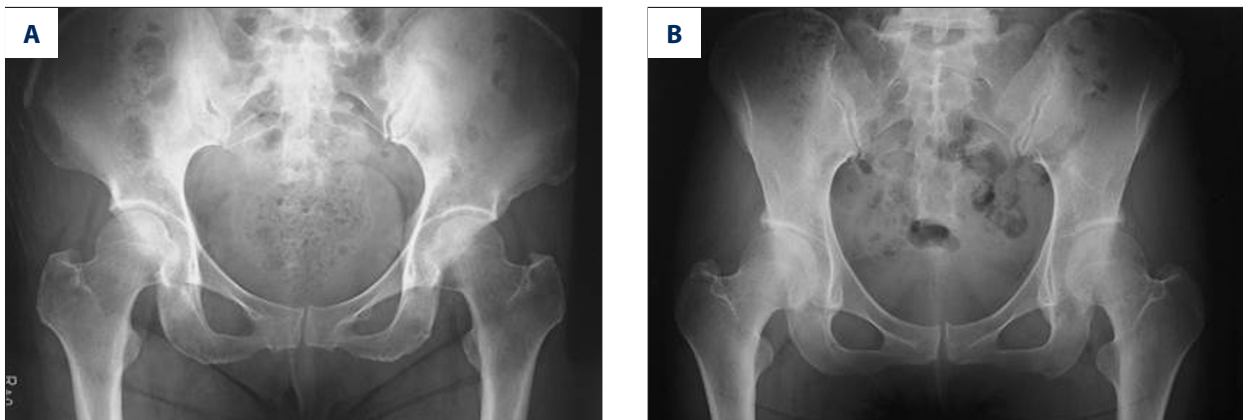


Figure 6. (A) Anteroposterior radiographs of a 48-year-old woman with bilateral avascular necrosis of the femoral head. Sharp angle is 41° in the right hip and 39° in the left hip. ASIS distance of this patient was 26.0 cm. (B) Anteroposterior radiographs of a 34-year-old woman with bilateral acetabular dysplasia of the hip. Sharp angle is 50° in the right hip and 49° in the left hip. ASIS distance of this patient was 22.0 cm.

ASIS distance. The ASIS distance may represent the transverse growth of the pelvis. These findings suggest that measurement of the ASIS distance could be used as a method for evaluation of the degree of AD.

The ASIS distance was significantly smaller in patients with relatively high-risk AD than in the lower risk patients for every AD parameter, suggesting that patients most likely to have hip OA due to AD had relatively small ASIS distances. In addition, according to the Sharp angle results, high-risk patients were taller than lower risk patients. Furthermore, the patients' heights did not differ on the basis of the other parameters of AD. These data suggest that the ASIS distance or possibly the transverse growth of the pelvis, but not the height of the patients, was involved in the risk of hip OA. These data also indicate that the ASIS distance is a marker for AD that has a high risk of hip OA, without considering patient height.

This study had several limitations. First, 176 female patients with hip OA were examined, but no healthy controls were examined. To clarify whether the ASIS distance can be used for detection of AD, another study that examines healthy controls is necessary. In the previous report of a study in the same series as the present study [1], the proportion of secondary hip OA-caused AD was significantly higher in female patients than in male patients. Approximately 84% of female hip OA was considered to be due to AD. Although this study did not include healthy controls, the female patients with hip OA were probably good subjects for examination of the relationship between the ASIS distance and AD. Second, the average BMI of the Japanese patients in our study was low compared with that of OA patients in United States (23.3 vs. 29.4) [22]. In races

that have a high rate of obesity, it may be difficult to precisely measure the ASIS distance.

There are also significant associations between ASIS distance and AHI, and acetabular roof obliquity angle. However, odds ratios and correlation coefficients were lower than those in cases of Sharp angle. AHI and acetabular roof obliquity angle reveals the relative position of the femoral head to the edge of the acetabulum and slope of the weight-bearing area of the acetabulum, respectively [20,21]. In contrast, the Sharp angle reveals the whole structure of the acetabulum [18] (Figure 1). Patients with AD have been reported to be associated with pathological transverse growth of the pelvis [14,15]. Small ASIS distance derived from pathological transverse growth of the pelvis might be associated with immature growth of the acetabulum, but not associated with the position of the femoral head or slope of the weight-bearing area (Figure 6).

Conclusions

In conclusion, the ASIS distance was correlated with the degree of AD in patients with hip OA in this study. The ASIS distance was smaller in patients with AD who were at high risk for hip OA than in patients at lower risk.

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