

Original article

Analysis of interobserver reliability for radiographic staging of coxarthrosis and indexes of acetabular dysplasia: a preliminary study

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Abstract

Background. We are planning a multicenter survey on coxarthrosis and acetabular dysplasia in Japan. To collect reliable data, we performed a preliminary study to elucidate the observer agreement on assessment items.

Methods. We collected radiographs of hip joints in eight patients with various findings of coxarthrosis. Twelve registered orthopedic specialists evaluated them regarding the roentgenographic stage of coxarthrosis and five indexes of acetabular dysplasia (acetabular angle, center-edge angle, acetabular roof obliquity, acetabular head quotient, approximate acetabular quotient). To assess observer agreement, we calculated the value of the kappa statistic for stages and the coefficient of variation for the indexes. The same 12 specialists then assessed the coxarthrosis stage on the same radiographs 1 month after the first evaluation based on our own descriptions of the roentgenographic stages.

Results. For the first evaluation of the roentgenographic stage, the value of the kappa statistic was 0.448; and for the second evaluation it was 0.600. The results of the coefficient of variation for the indexes of acetabular dysplasia, ranked in

ascending order, were as follows: acetabular angle, acetabular head quotient, acetabular roof obliquity, center-edge angle, approximate acetabular quotient.

Conclusions. For the upcoming multicenter survey, clear descriptions of the stages of coxarthrosis and selection of appropriate indexes can be helpful for collecting dependable results.

Introduction

Coxarthrosis is one of the major diseases that affect the healthy life-span of a population. To take systematic measures against it, we should know the actual situation of patients. There are, however, no nationwide data on this disorder in Japan. Hence, we are preparing a multicenter survey under the direction of one of the authors of this article (S.J.). Because many cases of coxarthrosis are considered to be secondary to acetabular dysplasia in this country,¹ we are including not only roentgenographic stages of coxarthrosis but also indexes of acetabular dysplasia in the assessment. Before undertaking

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such a large study and owing to the need for reliable data from the many institutions, it was necessary to examine the reproducibility of the roentgenographic stage classification and the acetabular dysplasia indexes. We therefore conducted this preliminary study of observer agreement on these items because there had been no such studies to investigate the issue previously.

Materials and methods

Study 1

One of the authors collected radiographs of the hip joints of eight patients with various radiological findings of coxarthrosis. These films had been obtained in his hospital with patients in a supine position. The target–film distance was 100 cm, and the X-ray beam was directed to the proximal margin of the symphysis pubis. Personal information was deleted, and a set of duplicate films were sent to 12 institutions: one in the Hokkaido region, one in the Tohoku region, two in the Kanto region, four in the Chubu region, one in the Chugoku-Shikoku region, and three in the Kyushu region. At each institution, one of the authors, a registered orthopedic specialist, evaluated the stage of coxarthrosis² and calculated five indexes of acetabular dysplasia: acetabular angle,³ center-edge (CE) angle,⁴ acetabular roof obliquity,⁵ acetabular head quotient (AHQ),⁶ approximate acetabular quotient (AAQ).⁶ Approval was given by the institutional review board to use the radiographs of hip osteoarthritis patients that had been obtained previously.

To determine the stage of coxarthrosis, we employed the classification proposed by the Japanese Orthopaedic Association's (JOA) committee on evaluation criteria for this condition (Table 1).² It defined five groups: almost normal, prearthrosis, initial stage, advanced stage, terminal stage. The committee focused on three

roentgenographic features: the width of the joint space, the structure of the bony architecture, the shape of the acetabular roof and the femoral head. There was, however, no description of groups or an authorized English translation.

Of the roentgenographic indexes of acetabular dysplasia, we used the line connecting bilateral teardrops as the transverse baseline for measurement. To measure the acetabular angle, the CE angle, the acetabular roof obliquity, and the AAQ, we identified the edge of the acetabular roof. When there was a spur at the lateral margin of the acetabulum, we did not employ the tip of the spur as a measuring point. Instead, we extended the lateral line of the ilium just proximal to the acetabulum distally and defined the point at the intersection with the sourcil as the lateral edge of the acetabulum.⁷

One of the authors, whose institution did not participate in film reading, performed the statistical analysis. For the stage of coxarthrosis, he computed the value of the kappa statistic⁸ and evaluated the strength of observer agreement.⁹ For the roentgenographic indexes, he set up a mixed linear model to calculate the coefficient of variation. In this model, the observer was viewed as a random effect, whereas the case, composite of the film number and the side, and the stage were viewed as fixed effects. Based on this premise, he calculated the coefficient of variation using the analysis of variance (ANOVA). When observers agreed well on the measurement of a certain index, its value of the coefficient of variation was small.

Study 2

To overcome the difficulty of staging coxarthrosis, we defined the stages from our own point of view and selected typical radiographs for reference (Table 2, Fig. 1). On the basis of this arrangement, the same 12 authors assessed the roentgenographic stage on the same radiographs again 1 month after Study 1.

Table 1. JOA staging criteria for coxarthrosis

Stage ^a	Joint space	Bony architecture	Shape of the acetabular roof and the femoral head
0	Almost normal	Almost no change	Almost normal
1	Slight incongruity, no narrowing	Changes in trabeculae	Congenital or acquired morphological change
2	Incongruity, partial narrowing	Sclerosis of the acetabulum	Small osteophyte
3	Incongruity, localized contact of the subchondral bones	Sclerosis of the acetabulum, bone cyst(s) in the acetabulum or the femoral head	Steophyte, bone formation on the acetabular floor
4	Incongruity, extensive disappearance of the joint space	Extensive sclerosis, large bone cyst(s)	Prominent osteophyte(s), double floor, destruction of the acetabulum

Translated by the authors from the original Japanese (ref. 2)

JOA, Japanese Orthopaedic Association

^a0, almost normal; 1, prearthrosis; 2, initial stage; 3, advanced stage; 4, terminal stage

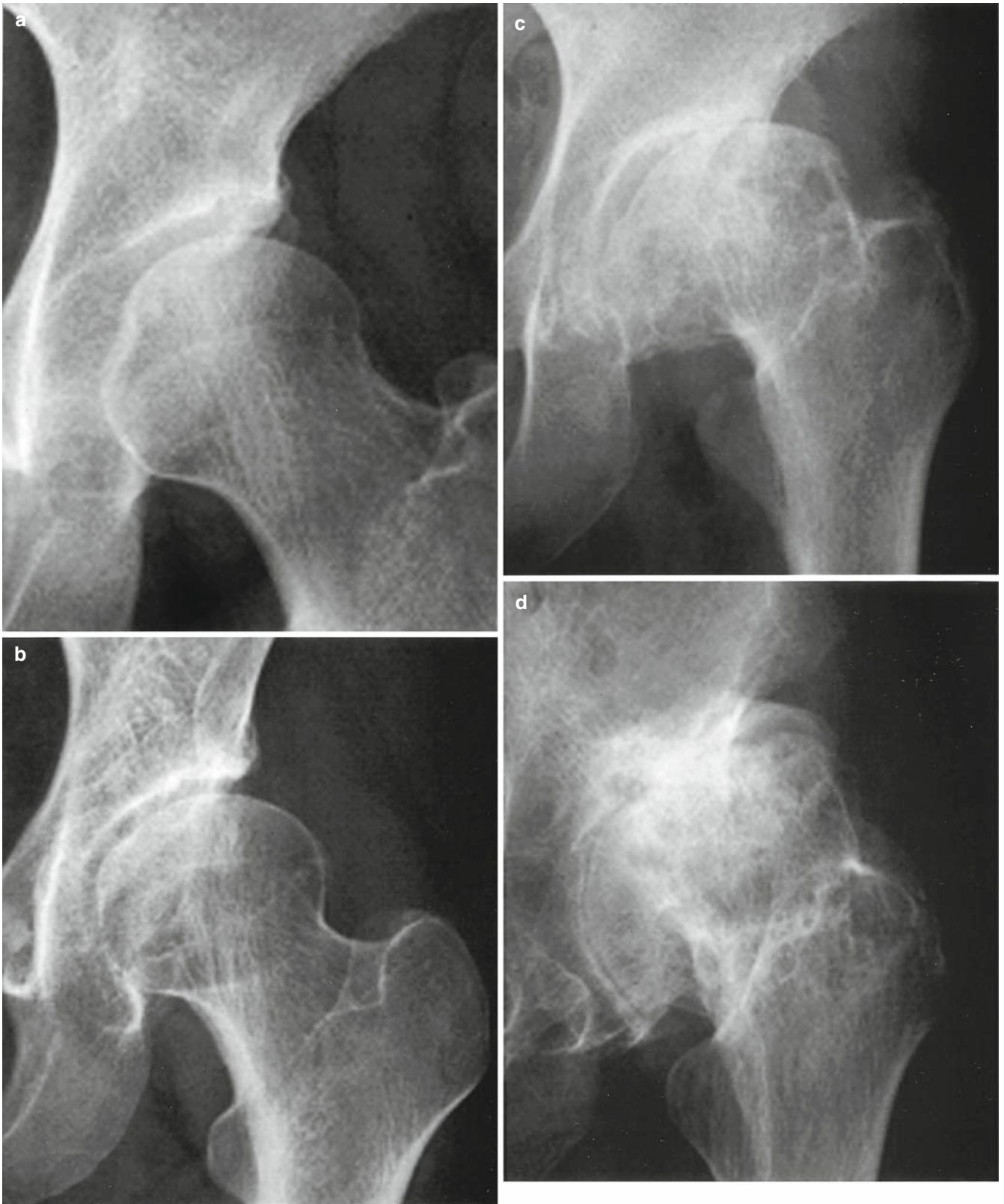


Fig. 1. Plain radiographs of the hip joint as references for staging coxarthrosis. **a** Prearthrosis. **b** Initial stage. **c** Advanced stage. **d** Terminal stage. (From Jingushi S. Osteoarthritis of

hips. In: Sugioka Y, Iwamoto Y, editors. Jinnaka's textbook of orthopaedic surgery. Tokyo: Nanzando; 2004. p. 809. With permission)

Table 2. Roentgenographic stages of coxarthrosis defined by the authors

Stage	Description
Prearthrosis	No arthrotic changes. ^a Morphological changes of the acetabulum and/or proximal femur related to osteoarthritis. ^b
Initial stage	One or more arthrotic changes. Possible narrowing of joint space. The width of joint space is maintained 2 mm or more throughout the weight-bearing area.
Advanced stage	Definite narrowing of joint space. The width is less than 2 mm at the thinnest point. Loss of joint space ^c is observed, and the width is less than 15 mm.
Terminal stage	Gross loss of joint space; the width is 15 mm or more.

^a Arthrotic changes: joint space narrowing, sclerosis, cyst formation, and osteophytes

^b Morphological changes related to osteoarthritis: acetabular dysplasia, femoral head deformity such as coxa plana, subluxation, and dislocation

^c Loss of joint space: the subchondral bone of the acetabulum is in contact with that of the femoral head

Table 3. Number of answers to roentgenographic stages (Study 1)

Film no.	Side	Stage ^a					
		0	0 or 1	1	2	3	4
1	Rt	0	2	5	4	0	0
1	Lt	0	1	7	3	0	0
2	Rt	8	3	0	0	0	0
2	Lt	0	0	0	0	7	4
3	Rt	5	3	1	2	0	0
3	Lt	0	0	1	2	8	0
4	Rt	0	0	0	1	10	0
4	Lt	0	0	1	9	1	0
5	Rt	0	0	0	8	3	0
5	Lt	5	2	3	1	0	0
6	Rt	5	3	3	0	0	0
6	Lt	1	3	7	0	0	0
7	Rt	0	0	0	0	0	11
7	Lt	7	3	0	1	0	0
8	Rt	8	2	0	1	0	0
8	Lt	5	2	2	2	0	0

^a See Table 1

Results

Study 1

Roentgenographic stages of coxarthrosis

Eleven researchers reported their first evaluations (Table 3). Disagreement was most apparent among the three groups of almost normal, prearthrosis, and the initial stage. Moreover, two or three observers classified nine hips as “almost normal or prearthrosis” (Fig. 2). Considering the power of statistical analysis, we dealt with these two categories as one unit. Consequently, the kappa statistic was calculated as 0.448, and the strength of agreement was evaluated as “moderate.”⁹

Roentgenographic indexes of acetabular dysplasia

All 12 researchers reported their first evaluations (Table 4). The value of the coefficient of variation was smallest for the acetabular angle and increased in the following order: AHQ, acetabular roof obliquity, CE angle, AAQ (Fig. 3). Thus, the observers had more agreement on the



Fig. 2. Film no. 1, right hip joint. Five researchers classified this hip joint as prearthrosis, four as the initial stage, and two as “almost normal or prearthrosis”

acetabular angle than on the CE angle, which are two representative indexes.

Study 2

All 12 researchers reported their results (Table 5). In this study, all researchers classified each hip as one of the five groups. The value of the kappa statistic was calculated as 0.600, and the strength of agreement was evaluated as “moderate.”⁹

Discussion

We found that the kappa statistic for the roentgenographic stage was as small as 0.448 in Study 1. This may

Table 4. Roentgenographic indexes of acetabular dysplasia

Film no.	Side	Indexes				
		Acetabular angle	Center-edge angle	Acetabular roof obliquity	Acetabular head quotient	Approximate acetabular quotient
1	Rt	46.4 ± 2.1	10.8 ± 3.8	26.8 ± 1.4	0.65 ± 0.04	0.19 ± 0.04
1	Lt	43.2 ± 2.5	15.4 ± 3.7	20.2 ± 1.8	0.69 ± 0.06	0.21 ± 0.05
2	Rt	40.8 ± 1.1	29.7 ± 2.3	10.4 ± 4.3	0.83 ± 0.03	0.26 ± 0.04
2	Lt	51.2 ± 3.3	-14.5 ± 19.0	40.9 ± 3.9	0.43 ± 0.11	0.07 ± 0.02
3	Rt	39.3 ± 2.2	27.0 ± 7.4	3.5 ± 5.9	0.79 ± 0.04	0.30 ± 0.05
3	Lt	51.3 ± 3.8	-0.75 ± 8.2	32.1 ± 4.4	0.51 ± 0.07	0.16 ± 0.03
4	Rt	49.6 ± 4.0	5.5 ± 7.3	33.8 ± 8.4	0.58 ± 0.08	0.21 ± 0.05
4	Lt	49.3 ± 3.3	9.6 ± 5.1	26.3 ± 2.7	0.60 ± 0.05	0.22 ± 0.03
5	Rt	40.5 ± 1.5	15.7 ± 6.1	21.2 ± 4.6	0.69 ± 0.03	0.18 ± 0.04
5	Lt	41.2 ± 2.6	24.6 ± 5.7	12.6 ± 2.7	0.82 ± 0.02	0.23 ± 0.04
6	Rt	41.3 ± 2.4	26.3 ± 4.5	8.5 ± 1.7	0.79 ± 0.02	0.26 ± 0.03
6	Lt	46.5 ± 2.6	18.6 ± 1.6	16.8 ± 1.3	0.70 ± 0.02	0.25 ± 0.04
7	Rt	45.9 ± 1.4	2.8 ± 5.2	13.3 ± 13.5	0.53 ± 0.03	0.21 ± 0.04
7	Lt	42.3 ± 2.9	30.6 ± 4.1	8.4 ± 5.6	0.85 ± 0.02	0.29 ± 0.09
8	Rt	38.8 ± 2.3	24.9 ± 4.3	10.1 ± 1.4	0.81 ± 0.04	0.23 ± 0.03
8	Lt	38.5 ± 2.0	27.4 ± 3.9	8.9 ± 3.1	0.81 ± 0.04	0.25 ± 0.03

Results are the mean ± standard deviation



Fig. 3. Film no. 2, left hip joint. The acetabular angle was reported to be $51.2^\circ \pm 3.3^\circ$, and the CE angle was $-14.5^\circ \pm 19.0^\circ$

be attributed to two causes. First, the researchers were trained in different centers. Fujii et al.¹⁰ performed a similar study using orthopedic surgeons who were trained in the same university hospital. They reported the value of the kappa statistic as 0.541. Second, the classification proposed by the JOA committee² bears the intrinsic ambiguity of the roentgenographic stage.

Table 5. Number of answers to roentgenographic stages (Study 2)

Film no.	Side	Stage ^a					
		0	0 or 1	1	2	3	4
1	Rt	0	3	7	2	0	0
1	Lt	0	1	6	5	0	0
2	Rt	7	3	2	0	0	0
2	Lt	0	0	0	0	9	3
3	Rt	5	1	1	5	0	0
3	Lt	0	0	0	4	8	0
4	Rt	0	0	0	0	12	0
4	Lt	0	0	0	10	2	0
5	Rt	0	0	0	10	2	0
5	Lt	5	2	3	2	0	0
6	Rt	4	3	5	0	0	0
6	Lt	1	3	8	0	0	0
7	Rt	0	0	0	0	0	12
7	Lt	6	2	0	4	0	0
8	Rt	6	3	2	1	0	0
8	Lt	4	3	3	2	0	0

^aSee Table 1

In fact, several registered orthopedic specialists found it difficult to distinguish the almost normal hip and the hip with prearthrosis. To eliminate ambiguity over the classification, we referred to preceding studies^{11,12} and then defined the stages from our own point of view. For example, we described the initial stage as the state in which the reduced joint space is maintained ≥ 2 mm throughout the weight-bearing area. Although the setting of ≥ 2 mm is arbitrary, we regarded the virtual existence of the articular cartilage as essential to draw a distinction between the initial stage and the advanced

stage. We also employed a width of 15 mm loss of joint space as a provisional boundary value between the advanced stage and the terminal stage. These refinements substantially improved observer agreement in Study 2. Our intention here is to define a modified classification so we can collect dependable results in our own multiinstitutional study; it is not to propose a new classification for general use.

Regarding the roentgenographic indexes of acetabular dysplasia, we obtained an unexpectedly large value for the coefficient of variation for the CE angle, one of the most popular indexes. This is probably due to the fact that we should determine the center of the femoral head to measure it. Whereas Wiberg showed radiographs in which the femoral head was round,⁴ several radiographs in our study showed heads that were severely deformed. According to the coefficient of variation values, the acetabular angle, AHQ, and acetabular oblique angle are more reliable for multicenter surveys than the CE angle or AHQ.

It is our belief that a clear description of the stages of coxarthrosis and selection of appropriate indexes can be helpful for collecting dependable results in our upcoming multicenter survey.

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