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PERTHES' DISEASE

A Study of Radiological Features

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A study is presented of the radiographs of 68 patients with unilateral Perthes' disease. Two types of Perthes' disease are identified: 'fragmenting' and 'non-fragmenting'. The two radiological types of the disease showed no significant differences in the age at diagnosis, the duration of symptoms before diagnosis and the duration of the disease. However, the radiologically-measurable results at healing, in terms of the epiphyseal, acetabular, acetabulum-head and comprehensive quotients were all very significantly worse when fragmentation had developed.

Key words: femoral head fragmentation; Perthes' disease

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The radiological features of Perthes' disease have been studied extensively since its first description in 1910 (Legg, Calvé, Perthes). Waldenström (1922) described the typical radiological changes of the condition, which included a stage during which the femoral head appeared to fragment. Ratliff (1956) and Somerville (1971) noted that fragmentation of the femoral capital epiphysis did not always occur in Perthes' disease and that in such patients the shape of the femoral head at the time of healing was 'perfect'.

On the basis of antero-posterior and lateral radiographs taken at onset, Waldenström (1938), Fèvre (1955) and O'Garra (1959) classified the disease according to whether the whole, or only part, of the femoral head appeared to be involved; they related the extent of involvement to the prognosis. Catterall (1971) described four different forms of Perthes' disease according to the amount of the femoral capital epiphysis affected by the disease as seen on the radiographs obtained at the time of diagnosis. Kamhi & McEwen (1975) stated that Catterall's classification could not be applied until the disease had progressed to the stage of fragmentation. Katz (1973) divided patients with Perthes' disease into three different groups, depending on the amount of the femoral epiphysis that appeared to fragment: accordingly his classification can be applied only at a late stage of the disease.

This paper reports a study of the radiographs of 68 patients with unilateral Perthes' disease, from diagnosis to healing. Some 46 patients showed radiological evidence of fragmentation of the femoral capital epiphysis.

PATIENTS AND METHODS

Patients. The children in this study had been treated as in-patients at three orthopaedic hospitals (The Marguerite Hepton Orthopaedic Hospital, Thorp Arch, Wetherby; The Woodlands Orthopaedic Hospital, Bradford; The Children's Hospital, Nottingham) during the years 1944 to 1970. The methods used for treatment included traction, Thomas' splint, rest on Jones' abduction frame, hip-spica, broomstick-plasters and patten ended calipers. None of the patients had been treated by surgery. Selection of the radiographs depended on the availability of antero-posterior and lateral views. Patients with bilateral disease were excluded because of the difficulty of assessing the radiological findings when no unaffected contralateral femur was available to act as a control. Of the 68 patients, 55 were boys and 13 girls.

Radiological assessments. The serial radiographs for each patient were examined and judged as to whether or not fragmentation had occurred in the femoral capital epiphysis during the natural history of the disease. The epiphysis was considered to have fragmented if a part, or the whole, of the bony nucleus showed the development of one or more separate fragments within, or at the periphery of, the nucleus. Healing was considered to have occurred when the radiological density throughout the femoral capital epiphysis, femoral neck and pelvis had returned to that observed in the opposite hip.

At healing each hip was assessed quantitatively using the techniques of Heyman & Herndon (1950). The following quotients were measused: the epiphyseal (EQ), the acetabular (AQ) and the acetabulum-head (AHQ); the mean of these quotients was called the 'comprehensive quotient' (CQ).

Statistical analysis. After categorizing the patients according to whether or not fragmentation had occurred, t-tests were performed for each of these quotients, EQ, AQ, AHQ and CQ. Similar tests were carried out for the two radiological types of the disease with respect to the age at diagnosis and the duration of the disease from diagnosis to healing. Further statistical analyses were undertaken to find whether the outcome of the disease was influenced by the sex of the patient, or the age at diagnosis (2–4 years, and over 6 years).

RESULTS

In 46 patients (38 boys and 8 girls) the femoral capital epiphysis had undergone fragmentation. In 22 patients (17 boys and 5 girls), the femoral capital epiphysis showed areas of increased and decreased density, irregularity of the outline of the bone nucleus, but no separate fragments. Examples of each radiological type during the active phase of the disease are shown in Figures 1 and 2.

The age at diagnosis, the duration of symptoms, the duration of the disease from diagnosis to healing and the results of the radiological assessments are summarized for the two types of the disease in Tables 1 and 2.

The radiographs of the 46 children with fragmentation often showed changes in the metaphysis and occasionally in the acetabulum (Figure 3). The AQ (Table 1, mean: 87.0) and the AHQ (Table 1, mean: 91.0) suggested that lasting damage to acetabulum had occurred. Moreover, the femoral head was markedly affected after fragmentation (Table 1, mean EQ: 67.4).

The radiographs of the 22 children with the non-fragmenting type of disease showed, despite the whole head involvement, that the end results were satisfactory. Metaphyseal changes, with an increase in the 'teardrop-distance' (Eyring et al. 1965), were frequently seen in the radiographs of these children (Figure 4). In this type of the disease only the capital femoral epiphysis showed lasting effects after the disease had healed (Table 2, mean EQ: 84.9). The acetabulum showed little sign of damage (Table 2, mean AQ: 98.7) and the femoral head remained well covered by the acetabulum (Table 2, mean AHQ: 97.7). The outcome of Perthes' disease of the non-fragmenting type was very satisfactory at healing (Table 2, mean CQ: 93.8).

Differences between the findings for fragmenting and non-fragmenting hips are highly significant (Table 3).

The radiographs obtained at an early stage did not distinguish between the two radiological types (Figures 1 and 2).

Table 1. Forty-six patients with the fragmenting type of unilateral Perthes' disease.

Initials	Age at diagnosis (years)	Length of history (weeks)	Length of disease (years)	Radiological assessment			
				EQ	AQ	AHQ	CQ
E.H.+	3	NK	3	45.6	103.6	91.1	80.1
M.H.+	4	20	3	58.1	93.8	65.1	72.3
K.J.+	5	6	2	77.3	87.4	84.3	83.0
B.T.+	5	NK	4	63.8	102.0	100.9	88.9
A.D.+	6	52	4	55.1	86.2	87.9	76.4
J.K.+	6	3	4	64.7	83.8	91.4	79.9
B.L.+	6	4	2	51.2	105.8	104.4	87.1
W.C.+	8	10	3	65.1	98.5	100.8	88.1
P.G.	3	NK	5	69.9	112.8	100.0	94.2
K.O.	3	1	2	87.7	79.9	95.5	87.7
R.P.	3	4	4	71.4	96.6	85.4	84.5
J.V.	3	1	3	58.3	82.9	123.2	88.1
D.W.	3	1	2	87.2	87.6	86.8	87.2
I.B.	4	26	2	79.4	80.4	98.2	86.0
R.J.	4	8	3	91.6	85.2	98.0	91.6
G.S.	4	6	5	91.2	100.0	86.5	92.6
R.T.	4	32	3	51.9	80.2	80.5	70.8
D.W.	4	12	7	69.3	45.8	92.8	69.3
A.C.	5	NK	1	66.3	63.2	100.9	76.8
M.C.	5	NK	2	89.7	89.3	107.8	95.6
C.H.	5	13	2	61.3	102.3	102.8	88.8
P.M.	5	1	3	66.1	86.9	85.7	79.6
D.P.	5	23	2	78.4	63.6	86.2	76.1
P.R.	5	4	3	40.8	60.6	71.1	57.5
J.W.	5	NK	2	59.9	94.1	84.2	79.4
S.W.	5	6	3	79.7	113.8	98.2	97.2
P.B.	6	2	2	49.4	100.7	91.9	80.7
K.D.	6	8	3	69.2	88.3	90.6	82.7
I.H.	6	3	3	67.6	83.1	95.0	81.9
A.S.	6	NK	1	65.1	90.5	94.7	83.5
M.S.	6	4	4	72.7	80.8	64.6	72.7
R.T.	6	NK	4	63.1	93.6	109.2	88.6
L.W.	6	0	2	72.8	114.0	94.0	93.6
P.W.	6	8	4	76.2	71.9	91.3	79.8
P.B.	7	4	3	48.7	63.9	67.6	60.1
A.H.	7	3	4	72.3	90.0	79.1	80.5
K.H.	7	5	2	64.4	72.0	93.2	76.5
B.L.	7	52	2	83.0	90.1	75.9	83.0
D.W.	7	NK	2	66.0	94.6	95.1	85.2
K.H.	8	NK	2	87.0	76.0	93.4	85.5
A.T.	8	8	3	65.9	96.8	95.0	85.9
R.B.	9	NK	2	72.3	65.0	79.6	72.3
D.B.	9	2	2	71.1	82.4	84.5	79.3
A.S.	9	3	3	54.9	83.7	93.3	77.3
R.B.	10	NK	1	60.6	67.3	89.7	72.5
R.W.	10	6	4	39.1	112.2	98.1	83.1
Mean	5.7	10.0	2.9	67.4	87.0	91.0	81.8

\+ = girls.
NK = not known.
0 = less than one week.

See text for radiological assessment abbreviations.

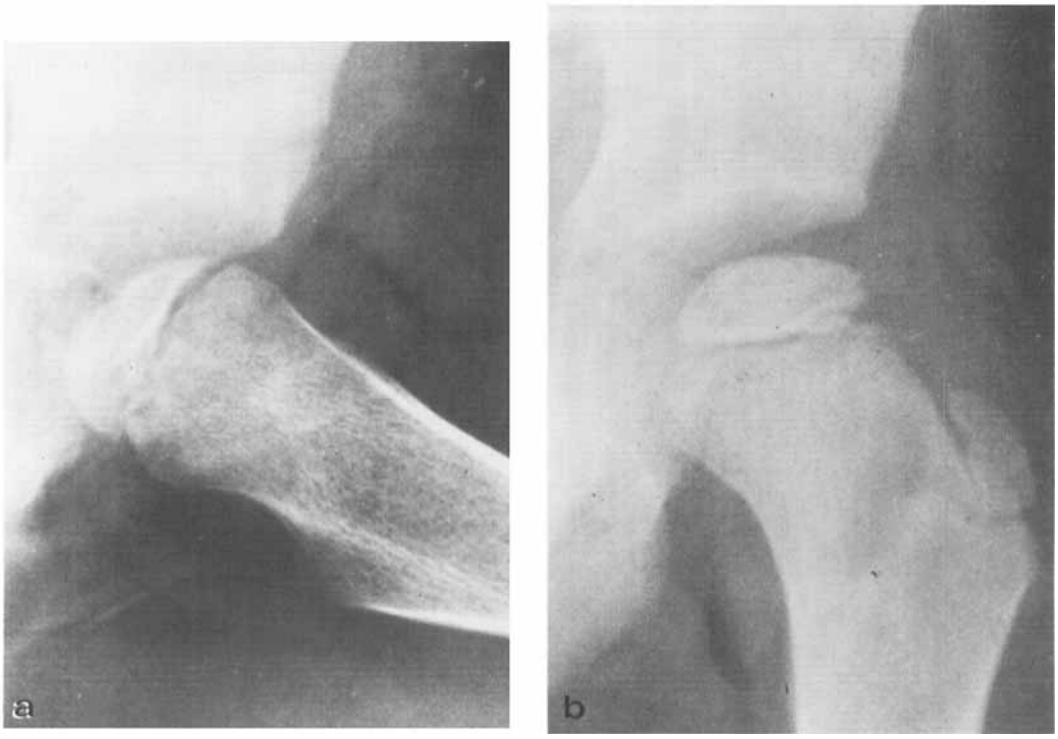

Figure 1. a, b. P.B., 7-year-old boy. Duration of symptoms: 4 weeks. Radiographs taken when the diagnosis was made.

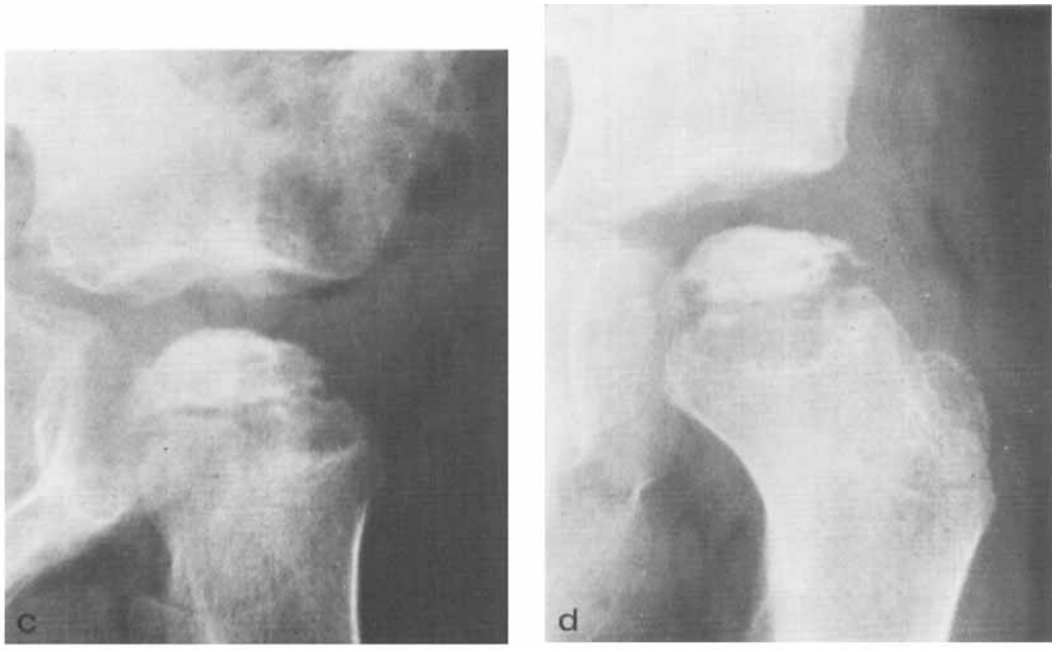

Figure 1. c, d. Radiographs taken 7 months after diagnosis. Fragmentation becoming evident. Metaphyseal changes are present. Catterall Group III.

Figure 1. e, f. 11 months after diagnosis. Fragmentation continues, 'head within the head' apparent.

Figure 1. g. 37 months after diagnosis. Healed Perthes' disease. EQ, 48.7; AQ, 63.9; AHQ, 67.6; CQ, 60.1.

Only later (from 4 to 18 months) did it become apparent which of the disease types was present. Once fragmentation is evident, Catterall's (1971) or Katz's (1973) classification can be used to assess the prognosis.

Tables 4 and 5 show there is no statistically significant difference between the two types of the disease with respect to the age at diagnosis, the duration of symptoms before diagnosis and the duration of the disease. Table 5 shows that the sex of the patient did not appear to influence the results as judged radiologically. Also, the duration of the disease in boys was similar to that in girls for both types of the disease. Table 6 shows that when we compare the radiological quotients in early-onset patients (2–4 years) with those for late-onset patients (6 years and above), the former enjoy, on the average, a slightly better result than late-onset patients, although only in two comparisons does the difference achieve conventional levels of significance.

Table 2. Twenty-two patients with the non-fragmenting type of unilateral Perthes' disease.

Initials	Age at diagnosis (years)	Length of history (weeks)	Length of disease (years)	Radiological assessment EQ	AQ	AHQ	CQ
J.A.+	3	NK	3	68.4	118.4	103.1	96.6
L.S.+	5	NK	2	91.2	100.0	102.6	97.9
T.D.+	6	5	2	75.1	95.9	94.2	88.4
M.F.+	6	NK	3	84.7	105.0	88.7	92.8
S.G.+	6	1	2	83.3	100.4	95.9	93.2
G.S.	2	1	5	100.0	101.8	98.2	100.0
J.B.	3	3	1	88.8	87.6	90.0	88.8
S.C.	3	NK	2	72.6	90.1	88.4	83.7
C.M.	3	NK	2	100.0	98.4	106.3	101.5
P.W.	3	6	4	84.4	86.9	112.6	94.6
S.B.	4	1	1	91.0	100.0	93.3	94.8
S.F.	4	12	3	82.7	102.6	110.3	98.5
J.P.	4	1	4	102.6	100.0	88.7	97.1
L.W.	4	1	2	100.0	115.3	91.9	102.4
T.D.	5	2	2	80.4	100.0	109.1	96.5
J.P.	5	NK	2	76.2	104.0	103.4	94.5
M.W.	5	0	2	93.6	85.9	106.9	95.5
A.B.	6	6	3	78.3	96.6	91.4	88.7
D.H.	6	37	2	94.0	96.9	91.1	94.0
P.B.	7	8	1	70.7	98.4	100.0	89.7
M.H.	8	8	3	67.6	92.7	92.9	84.4
K.T.	10	6	3	81.7	95.4	89.8	88.9
Mean	4.9	6.1	2.45	84.9	98.7	97.7	93.8

\+ = girls.
NK = not known.
0 = less than one week.

See text for radiological assessment abbreviations.

Table 3. Radiological quotients EQ, AQ, AHQ and CQ, in fragmenting and non-fragmenting types of unilateral Perthes' disease.

Radiological quotients	Groups tested (null hypothesis) Non-fragmenting versus fragmenting ($n = 22$) Mean	Standard deviation	($n = 46$) Mean	Standard deviation	P
EQ	84.9	10.7	67.4	13.0	* 8×10^{-7}
AQ	98.7	8.0	87.0	15.3	† 9×10^{-5}
AHQ	97.7	7.9	91.0	11.4	† 7×10^{-3}
CQ	93.8	5.1	81.8	8.4	† 8×10^{-10}

* t-test 2-tailed, equal variance.
† t-test 2-tailed, unequal variance.

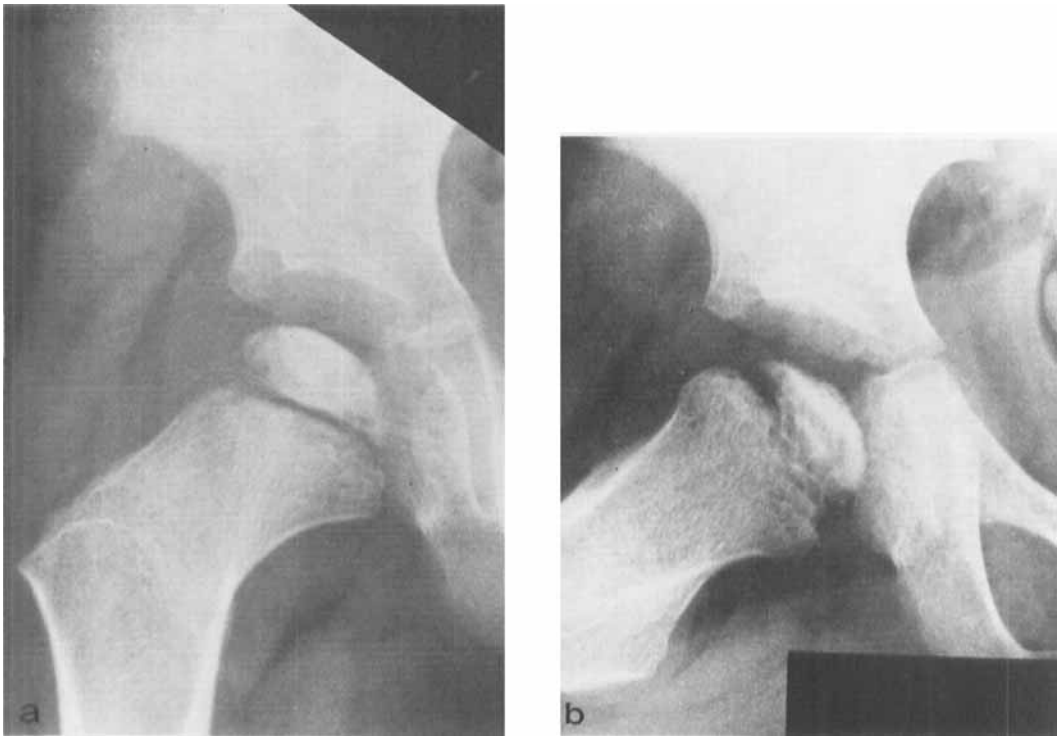

Figure 2. a, b. P.W., 3-year-old boy. Duration of symptoms: 6 weeks. Radiographs taken when the diagnosis was made. Changes in the metaphysis evident.

Table 4. Results of miscellaneous statistical tests.

Parameter compared	Non-fragmenting			Fragmenting			*P*	
	Mean	S.D.	*n*	Mean	S.D.	*n*		
Age at diagnosis	4.91 years	1.90 years	22	5.74 years	1.89 years	46	0.096	*
Duration of history	6.12 weeks	8.90 weeks	22	10.03 weeks	13.0 weeks	46	0.28	*
Duration of disease	2.45 years	1.01 years	22	2.87 years	1.17 years	46	0.16	*
Duration of disease, boys	2.47 years	0.55 years	17				0.89	*
Duration of disease, girls	2.40 years	1.12 years	5					
Duration of disease, boys				2.82 years	1.23 years	38	0.50	*
Duration of disease, girls				3.12 years	0.83 years	8		
Duration of disease, age at diag. 2–4 years	2.70 years	1.34 years	10				0.55	*
Duration of disease, age at diag. 6 years and above	2.38 years	0.74 years	8					
Duration of disease, age at diag. 2–4 years				3.50 years	1.51 years		0.14	†
Duration of disease, age at diag. 6 years and above				2.75 years	0.99 years			

* t-test 2-tailed, equal variance.
† t-test 2-tailed, unequal variance.

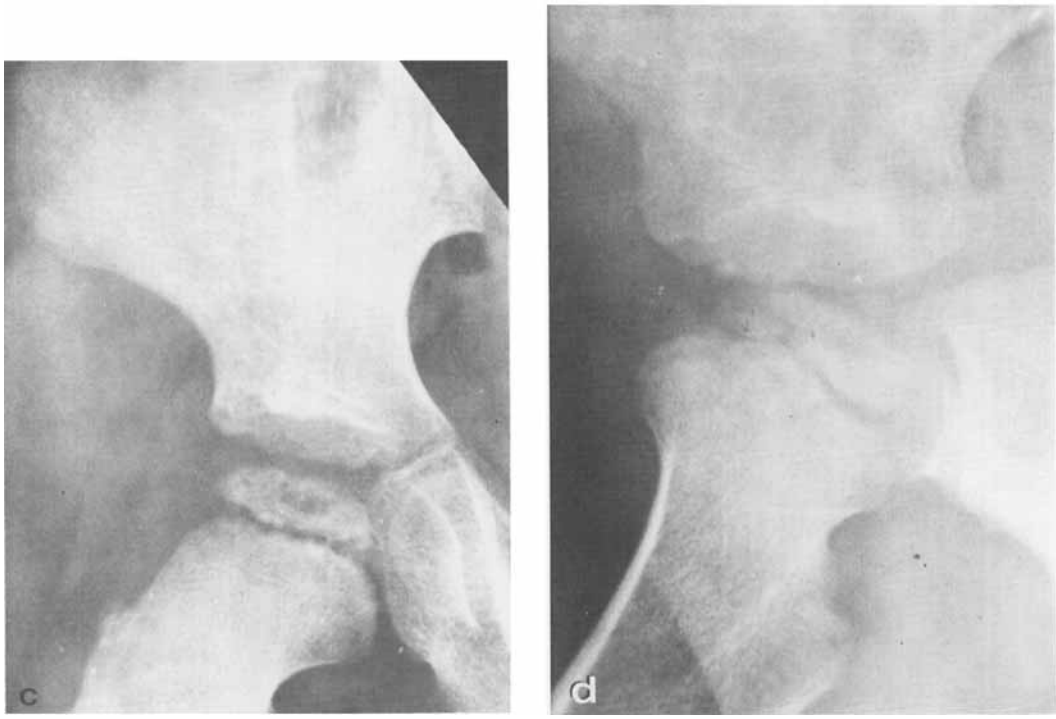

Figure 2. c, d. Radiographs taken 7 months after diagnosis. Irregularities in the density and outline of the capital epiphysis, but no separate fragment can be identified.

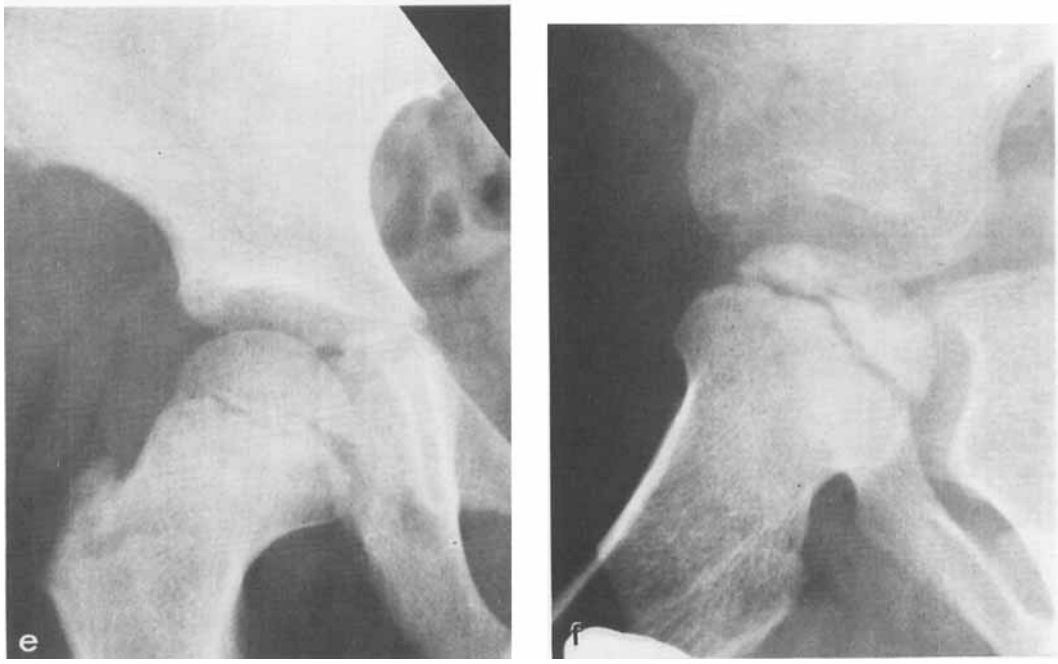

Figure 2. e, f. Radiographs taken 14 months after diagnosis. The radiological density of the capital epiphysis is still irregular, but there is no fragmentation.

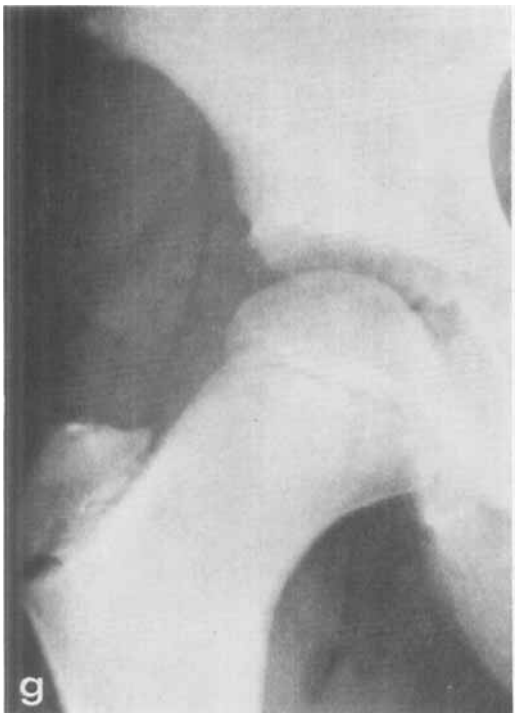

Figure 2 g. 48 months after diagnosis. Healed Perthes' disease. EQ, 84.4; AQ, 86.9; AHQ, 112.6; CQ, 94.6.

Figure 3. P.R., 5-year-old boy at the time of diagnosis of Perthes' disease. This radiograph was taken 18 months after diagnosis and shows changes in the acetabulum, in addition to the fragmentation of the capital epiphysis.

Table 5. Radiological quotients in girls compared with those in boys for fragmenting and non-fragmenting types of Perthes' disease.

Radiological quotients	Girls			Boys			P *
	Mean	S.D.	n	Mean	S.D.	n	
Non-fragmenting							
EQ	80.5	8.9	5	86.2	11.1	17	0.32
AQ	103.9	8.7	5	97.2	7.3	17	0.097
AHQ	96.9	6.1	5	97.9	8.5	17	0.81
CQ	93.8	3.7	5	93.7	5.6	17	0.99
Fragmenting							
EQ	60.1	9.8	8	69.0	13.2	38	0.080
AQ	95.1	8.6	8	85.3	15.9	38	0.099
AHQ	90.7	12.5	8	91.0	11.3	38	0.95
CQ	82.0	5.9	8	81.8	8.9	38	0.95

* t-test 2-tailed, equal variance.

Table 6. Radiological quotients in patients with the onset at 2 to 4 years compared with those in patients with the onset at 6 years and above.

Radiological quotients	Type	Groups tested (null hypothesis) Early onset Mean	S.D.	*n*	Late onset Mean	S.D.	*n*	*P*
EQ	Non-frag.	89.0	12.0	10	79.4	8.4	8	• 0.074
	Frag.	71.8	15.9	12	64.9	11.1	24	• 0.014
AQ	Non-frag.	100.1	10.6	10	97.7	3.7	8	† 0.51
	Frag.	87.4	16.8	12	87.1	13.7	24	• 0.96
AHQ	Non-frag.	98.3	9.2	10	93.0	3.7	8	† 0.12
	Frag.	91.9	13.8	12	90.0	10.5	24	* 0.64
CQ	Non-frag.	95.8	5.8	10	90.0	3.2	8	• 0.022
	Frag.	83.7	8.6	12	80.7	6.9	24	* 0.26

• t-test 2-tailed, equal variance.
† t-test 2-tailed, unequal variance.

Figure 4. T.D., 5-year-old boy. Duration of symptoms: 2 weeks. Radiographs taken at the time of diagnosis. The 'tear-drop distance' is increased on the right, and the outline of the right capital epiphysis is irregular. The femoral neck is broadened, and metaphyseal changes are evident. The child developed Perthes' disease of the non-fragmenting type.

DISCUSSION

Our radiological study delineates two different types of Perthes' disease. The fact that we found no significant differences between the types in the age at diagnosis, the duration of symptoms and the duration of the disease, suggests that we are observing the same basic disease in its less and more severe forms. We suggest, therefore, that the term 'dysplasia epiphysealis capitis femoris' (Pedersen 1960, Meyer 1964, Lauritzen 1975) should not be applied to the non-fragmenting type of the disease; we found no evidence to support Meyer's (1964) suggestion that this type of the disease develops in a previously malformed or dysplastic epiphysis.

The difference in the radiological course and the measurable results between the two types of the diseases is very marked. We find that, in the non-fragmenting type of disease only the capital epiphysis appears to be lastingly damaged although the whole of the epiphysis is clearly involved. In the fragmenting type, the acetabulum and also the relation of the femoral head to the acetabulum appear to have been disturbed, in addition to the deformity of the femoral capital epiphysis. The acetabular changes as described by the two quotients are perhaps secondary to the pathological process in the femoral head; it seems clear, however, that they occur only when the femoral capital epiphysis fragments.

Within the same type of Perthes' disease, the sex and the age of the patient at diagnosis appear to have little or no effect on the final outcome of the disease, although larger series are needed for definite conclusions.

As this study did not include the radio-

graphs of every child treated for Perthes' disease in the three hospitals during the indicated period, we can draw no firm conclusions about the relative frequency of occurrence of the two types. We can state, however, that if the diagnosis is made at an early stage it is not possible to judge from the radiographs which type of the disease will develop. Some 4 to 18 months later it will become clear which type of Perthes' disease is affecting the child. If fragmentation fails to appear on the radiographs, a relatively good prognosis can be given; if fragmentation manifests, Catterall's (1971) or Katz's (1973) classification helps to forecast the final results of the disease.

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