Avascular necrosis after nonoperative treatment of developmental hip dislocation

Prognosis in 36 patients followed 17–26 years

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36 children (61 hips) who had nonoperative treatment of developmental hip dislocation with the Frejka pillow and developed avascular necrosis were followed-up for an average of 20 (17–26) years. The radiographic pattern of necrosis was classified into 5 types. At final follow-up after completion of growth, the radiographic outcome was excellent in 11 hips, good in 21, fair in 19, and poor in 10 hips. There was a close correlation between the pattern of necrosis and the outcome: all the poor results were observed in cases with changes also involving the metaphysis.

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Avascular necrosis remains the most severe complication after treatment of developmental hip dislocation (DDH) in children (Tönnis 1982, Lempicki et al. 1990, Kruczynski et al. 1990). Abnormal growth of the hip with necrosis often leads to early arthrosis and disability (Cooperman et al. 1980, Rogala et al. 1988).

I studied the radiographic pattern of avascular necrosis and its correlation with the radiographic appearance after completion of growth.

Patients and methods

36 children (61 hips) who had nonoperative treatment of DDH with a Frejka pillow at our hospital during the period 1957–1969 complicated by avascular necrosis have been followed (Table 1). The criteria for selection of patients were complete radiographic documentation and a final examination after the end of growth.

The diagnosis of avascular necrosis was established according to the criteria of Salter et al. (1969), Gage and Winter (1972) and Bucholz and Ogden (1978). The average follow-up time was 20 (17–26) years.

The radiographic evaluation was based on radiographs taken at the initial assessment, at the age of 4–6 years and at the final assessment after completion of growth. The following parameters were measured: neck-shaft angle, head-neck index, articulo-trochanteric distance, acetabular index, acetabulum-head index, Wiberg CE angle, lateral displacement angle (Labaziewicz 1979) and head sphericity (Mose 1964). In addition, at the age of 4–6 years, the epiphyseal index, Alsberg angle and acetabular angle; and at the final evaluation, the angle of anteversion and head-shaft index (Kruczynski 1987) were determined.

On the basis of radiographically demonstrable changes in the epiphysis and metaphysis as the result of avascular necrosis, 5 types were identified (Figure 1):

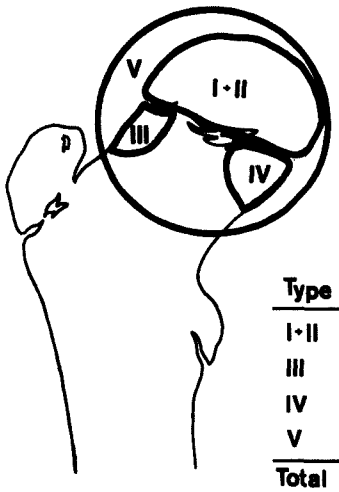
I. Involvement of the epiphysis, no fragmentation, mild changes (Figure 2).

II. Involvement of the epiphysis with fragmentation, moderate changes.

The difference between types I and II is that in the latter fragmentation of the epiphysis can also be observed (Figure 3).

Table 1. General characteristics of 36 patients (61 hips)

	Number of hips
Sex	
Boys	8
Girls	53
Hip	
Right	32
Left	29
Degree of dislocation	
Dislocation	44
Subluxation	9
Dysplasia	2
Contralateral hip	6



Type	Nº
I+II	30
III	16
IV	6
V	9
Total	61

Figure 1. Site of radiographic changes within the epiphysis and metaphysis due to avascular necrosis.

III. Involvement of the epiphysis and lateral part of the metaphysis under the physis, severe changes (Figure 4).

IV. Involvement of the epiphysis and the medial metaphysis under the physis, severe changes (Figure 5).

V. Involvement of the epiphysis and the entire metaphysis under the physis, severe changes (Figure 6).

The radiographic results were evaluated according to the modified criteria accepted at the XXVI Congress of the Polish Orthopaedic Association (Table 2).

Results

At the final examination there were 11 excellent, 21 good, 19 fair and 10 radiographically poor hips. All the poor results were observed in the 31 cases with

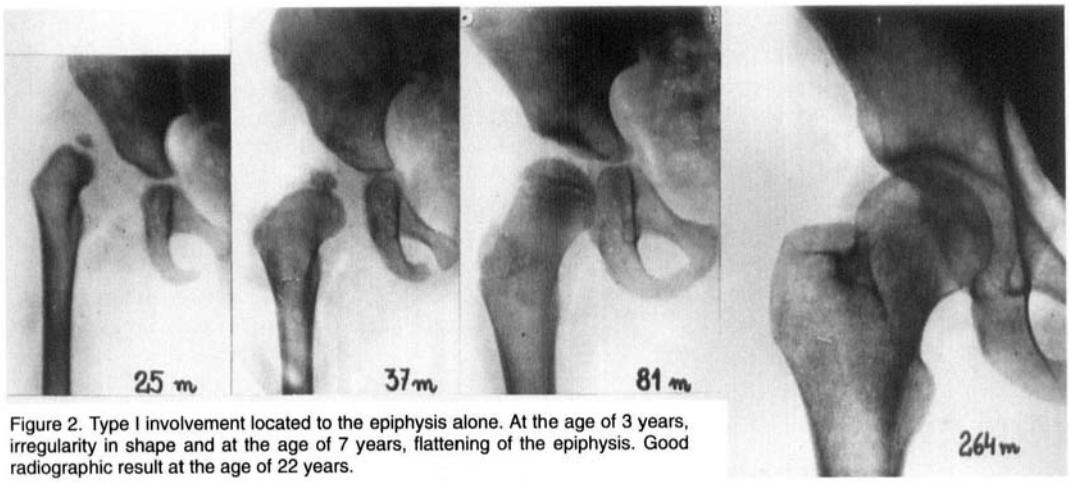


Figure 2. Type I involvement located to the epiphysis alone. At the age of 3 years, irregularity in shape and at the age of 7 years, flattening of the epiphysis. Good radiographic result at the age of 22 years.

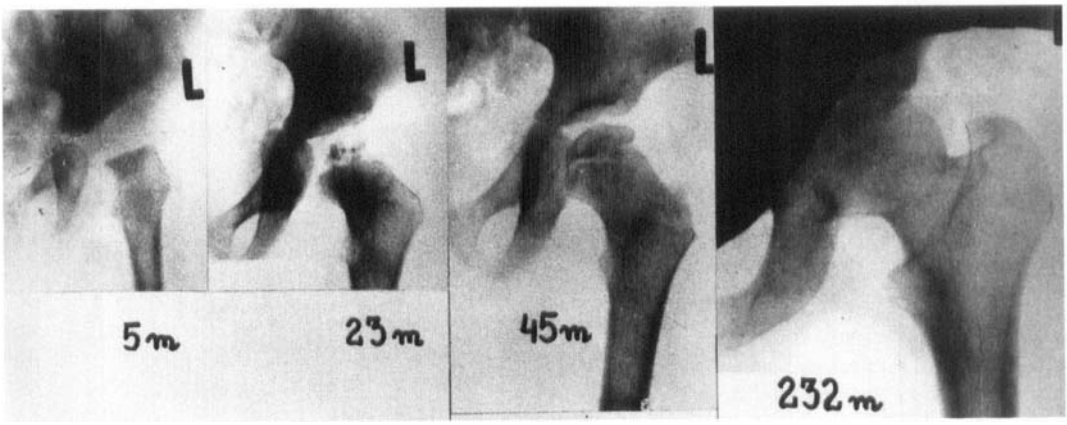


Figure 3. Type II involvement located to the epiphysis alone. At the age of 2 years, fragmentation and flattening of the epiphysis. Good radiographic result at the age of 19 years.

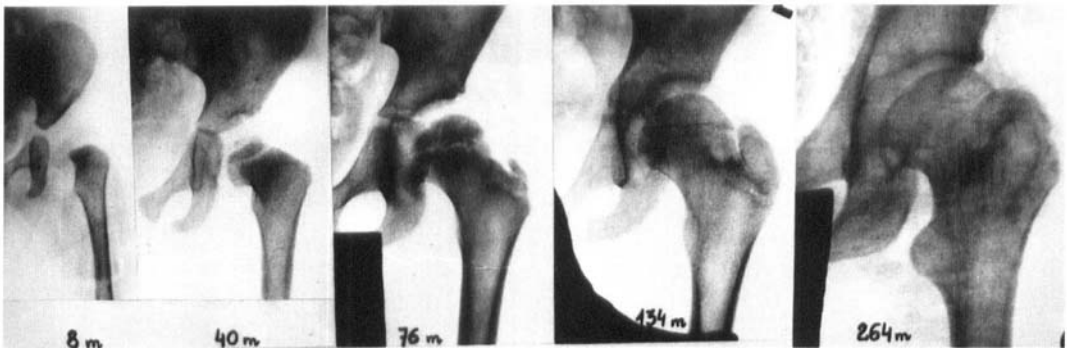


Figure 4. Type III involvement of the epiphysis and metaphysis. Lateral metaphyseal lesion at the age of 6 years. At the age of 11 years, the line of the physis is horizontal and metaphyseal cystic lesion still visible. Fair radiographic result at the age of 22 years with the epiphysis tilted into valgus angulation and uncovered.

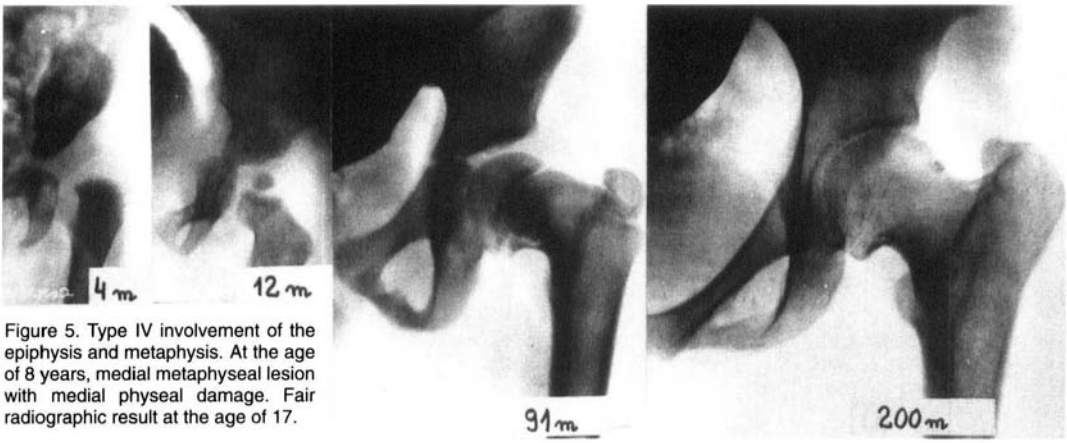


Figure 5. Type IV involvement of the epiphysis and metaphysis. At the age of 8 years, medial metaphyseal lesion with medial physeal damage. Fair radiographic result at the age of 17.

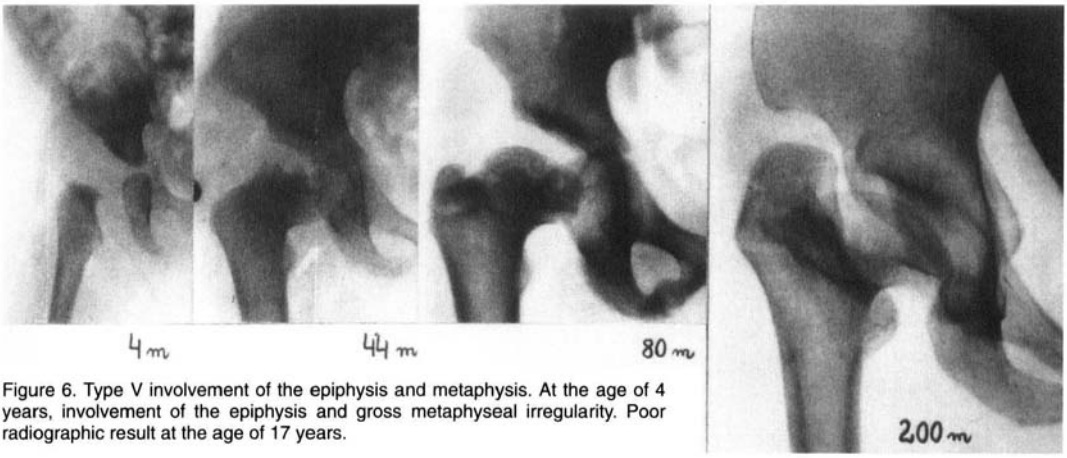


Figure 6. Type V involvement of the epiphysis and metaphysis. At the age of 4 years, involvement of the epiphysis and gross metaphyseal irregularity. Poor radiographic result at the age of 17 years.

radiographic changes involving also the metaphysis, types III–V (Table 3).

The values of the parameters varied according to the site of the radiographic changes of avascular necrosis. The main differences between types I and II at the age of 4–6 years were observed in the values of the epiphyseal index, head-neck index and the sphericity of the femoral head, with lower values in type II (Table 4). During the final examination, the latter was less visible and the main difference was in the angle of anteversion (Table 4). As indicated by the articulotrochanteric distance, there was an overgrowth of the

Table 2. Criteria for the radiographic evaluation

Result	A	B	C	D	E	F	G	H	I
Excellent	uninterrupted	<20	>25	10–40	120–140	well developed, head well covered	round	below center of the head	head well centered
Good	uninterrupted	21–24	20–24	0–9 41–50	110–119 141–155	slight uncovering irregular ossification	round, slight flattening	below the head surface	head well centered
Fair	slightly interrupted	>25	15–19	51–60	>155	uncovering, irregular ossification	significant flattening, spherical	on the level of the head surface	decentered hip, no subluxation
Poor									

A Shenton line
B Lateral displacement angle (Labaziewicz)
C Wiberg CE angle
D Anteversion angle
E Neck-shaft angle
F Acetabular roof
G Femoral head shape
H Position of the greater trochanter
I Femoral head-acetabulum centering

Table 3. Radiographic end-result in 61 hips with avascular necrosis in relation to the severity of necrosis

	Excellent	Good	Fair	Poor
Type I	5	14	5	–
II	2	2	2	–
III	3	3	6	4
IV	1	2	2	1
V	–	–	4	5

Table 4. Values of parameters measured at age 4–6 years (a), and at final assessment (b). Mean values in mm or degrees, *SD*

Type	I		II		III		IV		V	
Parameter	a	b	a	b	a	b	a	b	a	b
Neck-shaft angle	146 *3.6*	138 *3.4*	143 *5.5*	138 *8.1*	145 *9.1*	140 *9.7*	131 *8.1*	123 *9.4*	123 *14*	125 *14*
Epiphyseal index	43 *2.9*		40 *5.5*		34 *7.3*		42 *5.0*		28 *4.3*	
True neck-shaft angle		132 *3.2*		130 *7.7*		131 *7.9*		118 *7.4*		117 *12*
True angle of anteversion	35 *5.7*		41 *6.0*		39 *12*		33 *11*		40 *7.5*	
Head-neck index	155 *9.5*	159 *7.4*	149 *17*	159 *13*	154 *19*	153 *22*	155 *12*	158 *14*	128 *17*	115 *30*
ATD	19 *2.8*	20 *3.4*	18 *2.5*	20 *6.5*	18 *4.4*	14 *11*	15 *4.5*	9 *11*	10 *7.5*	3 *19*
Alsberg angle	74 *2.8*		71 *6.8*		76 *6.5*		51 *8.9*		54 *22*	
Acetabular index	26 *2.3*	34 *3.2*	25 *3.4*	32 *4.3*	27 *2.6*	31 *3.6*	23 *3.9*	29 *4.6*	22 *3.9*	25 *5.3*
Acetabular angle	20 *5.2*		22 *5.7*		20 *3.2*		24 *4.9*		25 *8.0*	
Acetabulum-head index	85 *7.5*	79 *6.6*	83 *8.5*	79 *8.5*	81 *8.3*	78 *8.0*	89 *5.9*	84 *8.4*	81 *8.8*	72 *12*
Wiberg CE angle	22 *5.1*	28 *4.8*	21 *5.9*	28 *7.3*	21 *5.1*	26 *9.5*	23 *6.0*	23 *10*	17 *4.8*	18 *13*
Lateral displacement angle	26 *3.2*	20 *1.7*	26 *3.5*	18 *5.3*	26 *3.5*	20 *4.6*	26 *2.4*	21 *6.2*	31 *4.0*	24 *5.2*
Head sphericity (Mose)	1.2 *0.4*	1.4 *0.5*	2.2 *1.1*	1.9 *0.8*	1.4 *0.6*	2.0 *1.0*	2.8 *1.3*	2.5 *1.7*	2.6 *1.2*	5.0 *2.0*
Head-shaft index		193 *21*		194 *14*		203 *20*		189 *8.8*		213 *13*

greater trochanter in types III, IV, and V with true coxa vara in types IV and V. In type V, all analyzed parameters indicated poor development of the hip.

Discussion

Most authors agree that avascular necrosis is an iatrogenic entity, although Herold (1979) found necrosis in 12 cases and Ferrer et al. (1991) in 34 cases of untreated developmental dislocation of the hip. Avascular necrosis may also be found in the contralateral hip treated for unilateral developmental dislocation (Salter et al. 1969, Gage and Winter 1972, Gore 1974, Westin and Ilfeld 1976, Fisher and Cary 1978, Visser 1984) and was found in 6 hips in my study with a fair radiographic result in one.

Siffert (1981) gave a detailed description of the growth zones of the hip and the patterns of deformity in the developing hip. It is well known that a deformity of the hip due to avascular necrosis depends primarily on the disturbance of the growth of the proximal femur (Gage and Winter 1972, Bucholz and Ogden 1978, Kalamchi and McEwen 1980, Siffert 1981). However, loss of head-acetabulum congruity places eccentric pressures on the rapidly growing impressionable cartilage, resulting in adaptive deformity of both structures (McKibbin 1970, Coleman 1978, Cooperman et al. 1980). The acetabular angle and acetabular index, which represent the growth of the acetabulum, were in my study low in hips with severe deformity of the proximal femur, in agreement with the findings of previous studies.

The severity of avascular necrosis may range from a mild degree of alteration in the epiphysis to involvement of the epiphysis and metaphysis with serious consequences. Several prognostic classifications have been proposed on the basis of the extent of involvement of the proximal femur (Gage and Winter 1972, Bucholz and Ogden 1978, Kalamchi and McEwen 1980, Tönnis 1984). The pattern of avascular necrosis adopted in this study distinguishes two types (I–II) of involvement of the epiphysis alone and three (III–V) of both the epiphysis and metaphysis. There was a good correlation between the types and the outcome with a good prognosis for types I and II hips and a poor prognosis for types III, IV, and V hips.

The sequence condensation-fragmentation-repair typical for Legg-Calvé-Perthes' disease is occasionally observed in avascular necrosis in developmental hip dislocation (Kohler and Seringe 1981) and I found it in only 1/10 of the hips with type II pattern. The differences in my classification between types I and II described by epiphyseal index and head sphericity were visible during the period of growth, with lower values in type II. After the end of growth, the epiphyseal index cannot be determined and the radiographic appearance of the epiphysis in these two types was similar.

The proposed classification permits prognosis of the final deformity in most of the hips, although it should be interpreted with caution. In some hips, the site of involvement of the proximal femur may be misleading. I agree with Robert and Seringe (1981) that avascular necrosis may take different radiographic forms which vary from those presented in the literature.

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