■ CHILDREN'S ORTHOPAEDICS

Long-term outcome of nonoperative treatment of Perthes' disease

ONLY 19% TOTAL HIP ARTHROPLASTY AT A MEAN FOLLOW-UP OF 48 YEARS

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Aims

The outcome in Perthes' disease deteriorates with increasing follow-up, ending with total hip arthroplasty (THA) in patients with severe complaints. The purpose of this study was to assess the prevalence of THA according to length of follow-up and to define risk factors for THA.

Methods

Patients were recruited from the radiological archive at Oslo University Hospital HF. In total, 229 patients (244 hips) were included in the study (184 males). The mean age at diagnosis was 6.2 years (2.1 to 13.7). A total of 105 hips (43%) were classified as spherical, 93 (38%) as ovoid, and 46 (19%) as flat. The mean time from diagnosis to follow-up was 48 years (27 to 72). Inclusion criteria were patients with nonoperative treatment for Perthes' disease and ≥ 25 years' follow-up. Sphericity of the femoral head at the healing stage was classified with the modified Stulberg method, which is a three-group classification based on the shape of the femoral head: spherical, ovoid, or flat. Information regarding THA was provided by the Norwegian Arthroplasty Register.

Results

Overall, 47 hips (19%) had undergone THA at a mean patient age of 46 years (22 to 72). The most important prognostic factors for THA were femoral head sphericity and age at onset. The frequency of THA was 3% in hips with spherical femoral heads, 25% in ovoid heads, and 46% in flat heads. Age ≥ six years was associated with THA more frequently than age < six years (28% and 10%, respectively). Kaplan-Meier survival analysis showed a survival rate at 50 years' follow-up of 99% (95% CI 96 to 100) in spherical hips, 76% (95% CI 66 to 86) in ovoid hips, and 48% (95% CI 29 to 67) in flat hips.

Conclusion

After a mean follow-up of 48 years, 47 of 244 nonoperatively treated hips had undergone THA (19%). The results indicate that the aim of treatment should be to obtain a spherical femoral head.

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Introduction

No consensus has been established with regard to treatment options for Perthes' disease. There is, however, a widely held opinion about the concept of containment to facilitate remodelling and thus lower the risk of deformation of the femoral head.[1-4] The most common surgical treatment to achieve containment is proximal femoral varus osteotomy and pelvic osteotomy, or a combination of both.[1-4] The principles of nonoperative treatment consist of physiotherapy to maintain range of motion, weightbearing relief, abduction orthosis, or simply observation without intervention. The clinical outcome after Perthes' disease will depend on the development of osteoarthritis (OA) later in life, which increases with the length of follow-up. Thus, long-term studies are necessary and few studies with longer than 40 years' follow-up have been published.[5-8] Although patient-reported outcome measures (PROMs) are the ideal standard to measure the clinical outcome, OA that causes reduction of quality of life will

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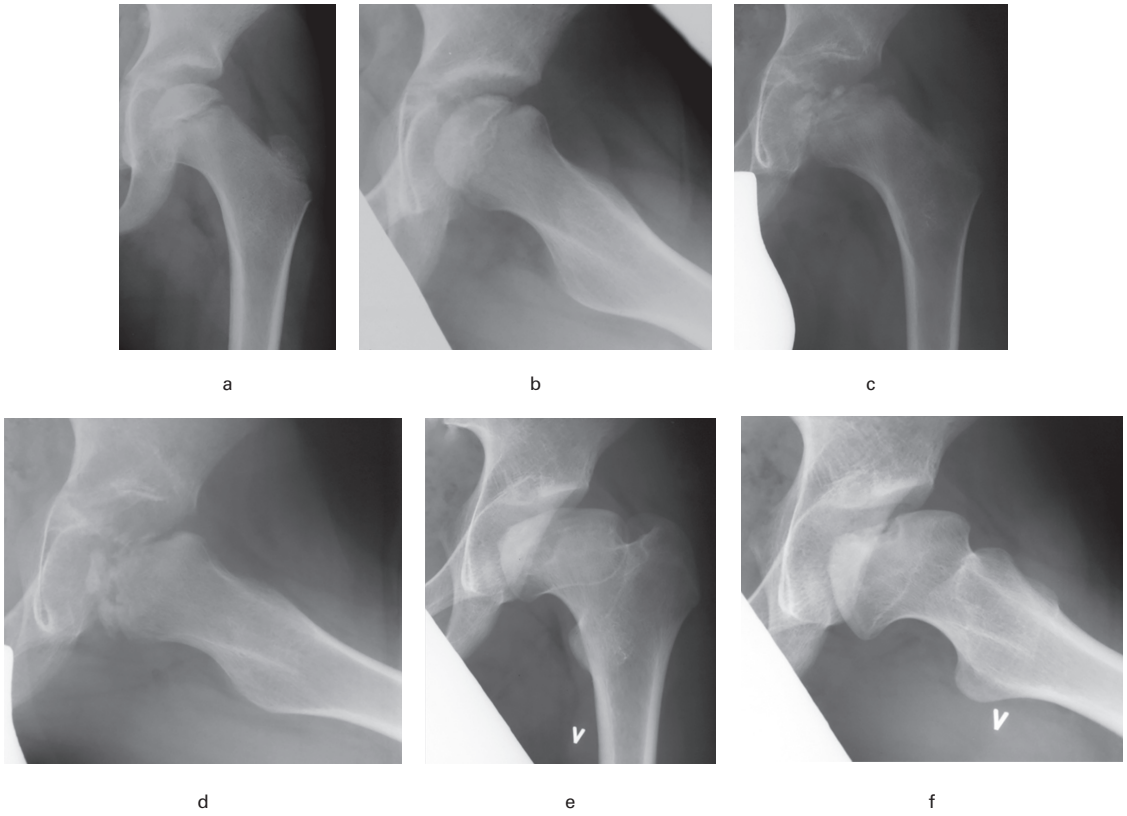

Fig. 1

a) Anteroposterior and b) lateral radiograph of the left hip at diagnosis in an eight-year-old male with Perthes' disease. c) Anteroposterior and d) lateral radiograph one year after diagnosis. e) Anteroposterior and f) lateral radiograph seven years after diagnosis. The hip is classified as flat according to the modified Stulberg classification.[13,14] The patient was treated with total hip arthroplasty 32 years after diagnosis.

frequently be treated with total hip arthroplasty (THA); therefore the prevalence of THA after Perthes' disease can also be used to define the outcome.

The Stulberg classification[9] has shown to be of prognostic value regarding the risk of THA.[6,7] However, in a recent meta-analysis by Zhi et al,[10] the risk of THA was similar in Stulberg I to II and III to V in nonoperatively treated patients. Older age at the onset of Perthes' disease has been accepted to be a risk factor for poor outcome; however, there are conflicting results according to long-term follow-up. McAndrew and Weinstein[5] found a strong correlation between age at onset and outcome in their 48-year follow-up study, while this was not found to be of prognostic value in a long-term follow-up study by Heesakkers et al.[11]

Before recommending surgical interventions, the outcome of nonoperative treatment and prognostic factors should be clarified. The purpose of this study was to evaluate the long-term prevalence of THA after nonoperative treatment according to the length of follow-up, and to define risk factors for poor outcome.

Methods

Patients were recruited from a search of the radiological files at Oslo University Hospital HF. Inclusion criteria were patients with nonoperative treatment for Perthes' disease, with adequate initial radiographs available, and with a minimum of 25 years' follow-up. Passive consent from the patients was required before inclusion, and the study was approved by the Regional Committee of Medical Research Ethics (ref. 306356) and our institutional review board (ref. 21/21661).

In total, 301 patients were identified from the radiological files. Of these, 72 patients were excluded for the following reasons: death (n = 29), unknown address (n = 9), refusal to participate (n = 5), and operative treatment (n = 29). Thus, 229 patients (244 hips) were included: 184 males and 45 females. Treatment was nonoperative with relief of weight-bearing and/or abduction orthosis; the choice of treatment was based on the routines and preference of the orthopaedic surgeon at the time.

Anteroposterior and lateral radiographs at one year after diagnosis were classified with the two-group modified Catterall classification; the original Catterall groups 1 and 2 were combined to group A (< 50% necrosis), and groups 3 and 4 were combined to group B (≥ 50% necrosis).[12,13] The femoral head at the healing stage was classified with the modified Stulberg method.[13,14] This is a three-group classification based on the shape of the femoral head: spherical, ovoid, or flat. According to the original Stulberg classification,[9] this modification defines

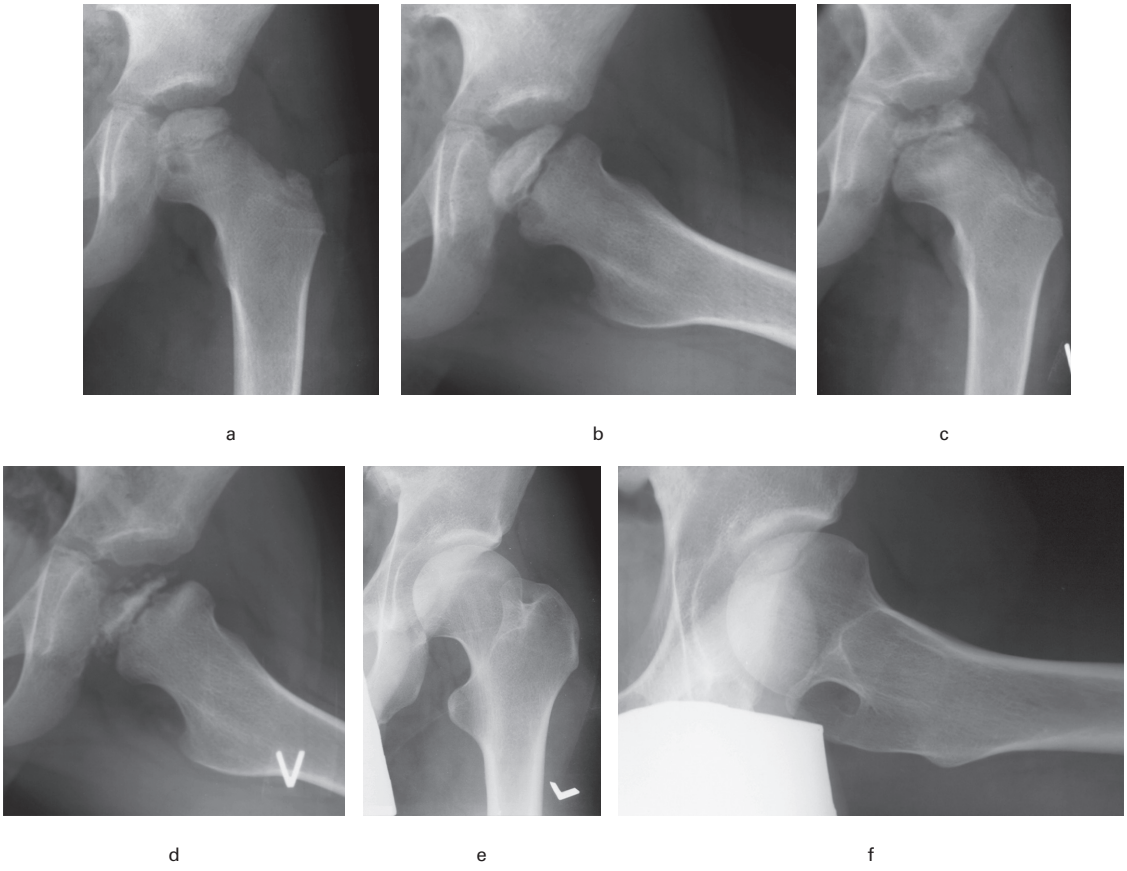

Fig. 2

a) Anteroposterior and b) lateral radiograph of the left hip at diagnosis in a five-year-old male with Perthes' disease. c) Anteroposterior and d) lateral radiograph one year after diagnosis. e) Anteroposterior and f) lateral radiograph 24 years after diagnosis. The left hip is classified as spherical according to the modified Stulberg classification.[13,14] The patient has his native hip at follow-up of 68 years.

Stulberg class I and II as spherical, Stulberg class III as ovoid, and Stulberg class IV and V as flat (Figures 1 and 2). The radiographs were classified by one unexperienced surgeon (CB) and two experienced surgeons (AW, SH). Agreement was set when at least two observers had the same Catterall group and modified Stulberg category. We used subjective evaluation to define Stulberg category, however, in borderline cases, we used digital templates with concentric circles to define the category. Before the radiological classification, we carried out a consensus meeting regarding how to define the different categories.

Information regarding THA was provided by the Norwegian Arthroplasty Register (NAR), which is a nationwide register that was established in 1987 and approved as a National Quality Register in 2009.[15] The main purpose of this register is to uncover inferior arthroplasty implants by measuring the risk for revision. The data from NAR were received in June 2023.

Patient characteristics. The patients included in the study were diagnosed between 1950 and 1995. The mean age at diagnosis was 6.2 years (2 to 13). A total of 27 hips (11%) were classified as modified Catterall group A (< 50% necrosis) and 217 hips (89%) as modified group B (≥ 50% necrosis). At the healing stage, femoral head shape was classified as spherical (Stulberg group I/II) in 105 hips (43%), ovoid (Stulberg group III) in 93 hips (38%), and flat (Stulberg group IV/V) in 46 hips (19%).

The mean time from diagnosis to follow-up was 48 years (27 to 72). At follow-up, 47 hips (19%) had undergone THA at a mean patient age of 46 years (22 to 72). Most of the THAs (26 of 47) were performed during the last ten years of the follow-up time (2014 to 2023).

Possible risk factors for requiring THA shown in Table I were subject to univariable logistic regression analysis. Female sex, age at onset ≥ six years, Catterall modified group B (≥ 50% necrosis), and higher Stulberg groups were all found to be statistically significant risk factors and were included in a multivariable logistic regression analysis.

Statistical analysis. SPSS v. 28 (IBM, USA) was used for the statistical analysis. Categorical data were analyzed with the chi-squared test, and continuous data with the independent-samples *t*-test. Univariable and multivariable logistic regression were used for the analysis of predictive factors for good (no THA) and poor (THA) long-term outcomes. Kaplan-Meier survival analysis with conversion to THA as the endpoint was used to find the proportion of hips that had undergone THA at different durations of follow-up. Differences were considered statistically significant when the two-sided p-value was < 0.05.

Table I. Possible risk factors for total hip arthroplasty.

Variable	Hips, n	Univariable analysis			Multivariable analysis	
		No THA	THA	p-value	OR (95% CI)	p-value
Sex				0.014	4.1 (1.7 to 9.7)	0.002
Female	47	32	15			
Male	197	165	32			
Side				0.803		
Right	118	94	24			
Left	126	103	23			
Age at diagnosis				< 0.001	2.7 (1.2 to 6.0)	0.013
< 6 yrs	124	111	13			
≥ 6 yrs	120	86	34			
Modified Catterall*				0.014		
Group A (< 50% necrosis)	23	23	0			
Group B (≥ 50% necrosis)	221	174	47			
Modified Stulberg classification				< 0.001	4.4 (2.6 to 7.6)	< 0.001
I/II	105	102	3			
III	93	70	23			
IV/V	46	25	21			

*Modified Catterall groups were not included in the multivariable logistic regression analysis as there were no hips with THA in group A.
OR, odds ratio; THA, total hip arthroplasty.

Table II. Kaplan-Meier survival with 95% CI with total hip arthroplasty as the endpoint according to the modified Stulberg classification[13,14] (spherical, ovoid, or flat femoral head) at the healing stage.

Years follow-up	Survival (95% CI)		
	Spherical (n = 105)	Ovoid (n = 93)	Flat (n = 46)
20	100	99 (97 to 100)	98 (94 to 100)
30	100	98 (95 to 100)	89 (80 to 98)
40	100	89 (82 to 96)	61 (46 to 76)
50	99 (96 to 100)	76 (66 to 86)	48 (29 to 67)
55	92 (83 to 100)	67 (54 to 80)	

Results

The rate of THA in children aged ≥ six years at diagnosis was 28%, and the rate in those < six years was 10%. The frequency of THA was three of 105 hips (3%) with spherical femoral heads, 23 of 93 ovoid hips (25%), and 21 of 46 (46%) hips with flat femoral heads. The findings of the multiple variable logistic regression model were similar to the univariable results with female sex, age at onset ≥ six years, Catterall modified group B (≥ 50% necrosis), and higher Stulberg groups all being statistically significant risk factors for requiring THA (Table I). Kaplan-Meier survival analysis with conversion to THA as the endpoint showed very high survival at 20 years' follow-up, with rates of 100% (105 at risk) in spherical hips, 99% (95% CI 97 to 100; 92 at risk) in ovoid hips, and 98% (95% CI 94 to 100; 45 at risk) in flat hips. With longer follow-up, the survival decreased in all three Stulberg groups, but more in the two non-spherical groups than in spherical hips, ending with survival rates at 50 years' follow-up of 99% (95% CI 96 to 100; 50 at risk) in spherical hips, 76% (95% CI 66 to 86; 32 at risk) in ovoid hips, and 48% (95% CI 29 to 67; seven at risk) in flat hips (Figure 3, Table II).

Discussion

The overall rate of THA in this study, at a mean follow-up of 48 years, was 47 of 244 hips (19%). There are few previous studies with a follow-up of more than 40 years. In a Danish study using THA data from the Danish arthroplasty register,[7] the mean follow-up time was 47 years and the patients had been treated with Thomas splint. They found a prevalence of THA of only 13%. Other studies of nonoperative treatment reported higher rates of THA: 40% at 48 years' follow-up[5] and 24% at 50 years' follow-up.[6] The longest follow-up after operative treatment with varus derotational osteotomy seems to be the study by Shohat et al,[8] including 41 hips with a mean follow-up time of 42 years. Their Stulberg distribution showed somewhat fewer hips with Stulberg III to V (43%) than in our study (57%), but their rate of THA was 17% and thus similar to ours. Our result with 19% THA at a mean follow-up of 48 years should be compared with the prevalence of THA in the general population. In a paper from UK,[16] the lifetime risk of THA at age 50 years for the year 2005 was 11.6% for females and 7.1% for males. In Norway, the lifetime risk of THA from OA in 2013 was estimated to be 16.0% for females and 8.3% for males.[17]

At the healing stage, the distribution of hips according to the modified Stulberg groups was 43% round femoral heads, 38% ovoid heads, and 19% flat heads. These frequencies are within the ranges reported in previous studies where the Stulberg classification was used.[2,7–9,18,19] The distribution of sphericity in these studies was a median frequency of 50% (range 32 to 67) in Stulberg groups I/II, 26% (range 11 to 38) in Stulberg III,

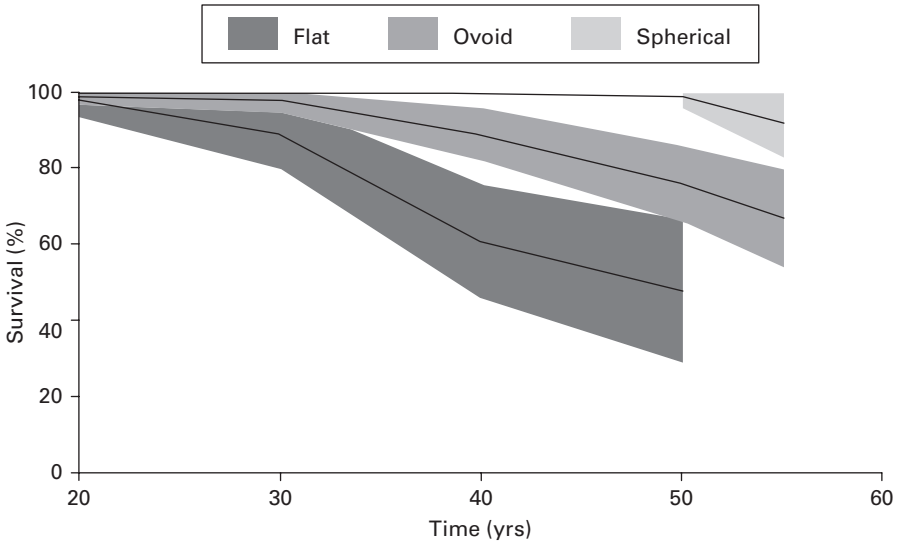

Fig. 3

Kaplan-Meier survival analysis with total hip arthroplasty as the endpoint according to the modified Stulberg classification[13,14] (spherical, ovoid, or flat femoral head) at the healing stage.

and 23% (range 15 to 51) in Stulberg groups IV/V. In one study, a modified Stulberg classification including only two groups was used: groups I/II compared with groups III/IV/V.[8] Since we found significant differences in the rate of THA between Stulberg I/II and III and between Stulberg III and IV/V, omission of Stulberg group III as a separate group should be avoided.

The degree of sphericity of the femoral head was a statistically significant prognostic factor in this study. In particular, a flat femoral head was a crucial risk factor. The difference in outcome was stark with only three of 105 hips (3%) with a spherical femoral head requiring THA in contrast with 21 of 46 hips (46%) of those with a flat femoral head who had been treated with THA. This marked impact of femoral head shape supports the experience of other long-term studies on the frequency of THA.[6-8] Surprisingly, a recent review article found that the Stulberg classification "was not directly associated with the incidence of THA".[10] The three-group modification of the Stulberg classification is relatively easy to perform, has an acceptable interobserver agreement between experienced examiners,[13] and is therefore recommended for routine clinical use. Similar classifications like the original Stulberg method[9] and the method described by Mose[20] seem more complicated and subjective. In the present study, the outcome was not evaluated with PROMs. However, in a study of 136 individuals at a mean age of 24 years (12 to 55) with Perthes' disease from the UK,[21] spherical hips were associated with the highest function and quality of life, and lowest pain, which matched well with our results.

Older age at onset of Perthes' disease was a clear risk factor for THA in this study, in accordance with some previous long-term studies.[5,10,20,22] However, age at diagnosis was not found to be a prognostic factor by Heesakkers et al.[11] In accordance with the Norwegian multicentre study,[3] we found that children older than six years had a worse prognosis than that of younger children, whereas an age limit of eight years was reported by Herring et al.[2] Female sex was a prognostic factor for THA in accordance with some earlier studies that females have worse outcome of Perthes' disease than males.[12,23]

The purpose of this study was to evaluate the long-term outcome after nonoperative treatment. The patients were diagnosed through a long period of time and thus the methods of conservative treatment varied. Accordingly, the results cannot be directly compared with more modern, specific protocols including orthoses, hip range of motion exercises and prolonged non-weightbearing. Although the short-term results of such methods have been promising,[4,24] longer follow-up is needed before reliable prognostic conclusions can be drawn.

Our study has some limitations. First, this was a retrospective study with no control group, and it has been shown that retrospective studies with positive outcome reporting are frequent in studies on the treatment of Perthes' disease.[25] Second, poor outcome was defined as the need of THA, and the outcome of the rest of the cohort was not evaluated. In a study from The International Perthes Study Group with 921 participants with Perthes' disease without THA, statistically significantly lower Hip disability and Osteoarthritis Outcome Score (HOOS)[26] and 36-Item Short-Form Health Survey questionnaire (SF-36)[27] scores were found compared with an age- and sex-matched normative cohort.[28] This indicates that the overall results in our study would have been less favourable if clinical outcome had been studied, since an unknown proportion of patients probably had hip pain and reduced function, but not to the extent that they had found it necessary to undergo THA. Third, although NAR was established in 1987 and has a very good degree of coverage (97% of the primary THAs in Norway are reported to the register), some patients could have been treated with THA before 1987. We believe, however, that this number is very low, since the mean follow-up time in 1987 was only 13 years

and the indication for THA in younger individuals at that time was stricter than today. The strengths of this study are the large number of patients and the long follow-up time.

In conclusion, our long-term study with a mean 48 years' follow-up has revealed that patients aged over six years at diagnosis and a flat femoral head at the healing stage are important risk factors for poor outcome. This confirms the experience from the Norwegian Perthes' study at five-year follow-up[3] and 21-year follow-up.[14] This indicates that the aim of treatment should be to obtain a spherical femoral head.

Take home message

- The rate of total hip arthroplasty after nonoperative treatment of Perthes' disease was 19% at a mean follow-up of 48 years.
- The most important prognostic factor was the shape of the femoral head.
- Thus, the aim of treatment should be to obtain a spherical femoral head.

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