Salter's innominate osteotomy for hip dysplasia in adolescents and young adults

Results in 58 patients (69 osteotomies) at 4–12 years

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Submitted 01-04-21. Accepted 02-10-20

ABSTRACT **We reviewed 69 Salter's innominate osteotomies (SIO) in 58 patients with developmental dysplasia of the hip. Their mean age at operation was 22 (13–37) years. 24 hips were operated on in patients under 18 years of age (adolescents) and 45 hips in patients 18 years or over (adults).**

The mean follow-up was 7.6 (3.8–12) years. The mean Harris hip score (HHS)/Merle d'Aubigné score improved from 66 (38–97)/14.0 (8.0–18) points before surgery to 81 (22–100) points/15 (6–18) points at final review. Using the endpoints total hip arthroplasty and a Merle d'Aubigné score of < 13 and/or a HHS < 71, 13 of the 69 hips had failed and the cumulative survival rate was 0.79 (95% CI, 0.69–0.89) at 12 years. Their age at operation and the grade of preoperative coxarthrosis affected the clinical outcome. No deterioration in the mean grade of coxarthrosis was noted at final review, as compared to the condition before surgery.

We conclude that the SIO is a well-standardized operation, with a low risk of complications, which gives encouraging results in adolescents and young adults with or without mild arthrosis. The operation may retard or even arrest the coxarthrosis.

The rationale of Salter's innominate osteotomy (SIO) is stabilization of the hip by redirection of the maldirected acetabulum. In his first report, Salter (1961) recommended the use of SIO only in children aged 18 months to 6 years. Later on, he extended the indication for SIO to young adults (Salter et al. 1984). Meanwhile, alternative redirection osteotomies of the acetabulum, including double innominate osteotomies and various types of triple and periacetabular osteotomies, have been developed (Wagner 1965, Steel 1973, Sutherland and Greenfield 1977, Kotz et al. 1992, Tönnis et al. 1994, Trousdale et al. 1995). Ultimately, the success of an operation depends on its clinical results. We evaluated a consecutive series of SIOs performed in adolescents and adults to compare our results with other types of acetabular reorientation osteotomies.

Patients and methods

72 consecutive Salter's innominate osteotomies (SIOs) were performed in 61 adolescent or adult patients more than 12 years of age between March 1987 and May 1995. 2 patients with underlying neurological disease (cerebral palsy and multiple sclerosis) were excluded, and 1 was lost to follow-up. Thus, 69 hips in 58 patients (15 male) were evaluated. The average age of all patients at the time of operation was 22 (13–37) years, 19 (13–37) years for male patients, and 23 (13–36) years in female patients. 41 right hips and 28 left had been operated on—i.e., in 47 cases the osteotomy was done on one side; surgical treatment was necessary in 30 right hips, as compared to 17 left hips. The primary diagnosis was developmental dysplasia of the hip (DDH) in 68 hips—16 of them with congenital dislocation—and hip dysplasia due to multiple epiphyseal dysplasia in 1. In 31 hips, 17 surgical procedures preceded the index operation: open reduction 5, intertrochanteric osteotomy

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8, acetabuloplasty 3, and epiphyseodesis of the greater trochanter 1.

The surgical technique was precisely the same as that described by Salter (Salter 1961, Salter et al. 1984). In 57 hips, the index SIO was performed solely; in 12 hips, SIO was combined with intertrochanteric osteotomy; in 2 hips with drilling of the femoral head, and in 1 hip, the SIO was combined with distalization of the greater trochanter.

After a mean follow-up of 7.6 (3.8–12) years, evaluation of the functional and radiographic results was performed by an unbiased investigator who was not a member of the staff in the department (GW). At the time of operation, 19 patients (24 hips) were younger than 18 years (adolescent group) and 39 (45 hips) were 18 years or older (adult group). 1 patient was 17.6 years old when the right hip was operated and 18.6 years old when the left side was operated on. She was regarded as an adult, when her ability to walk was assessed. At the latest follow-up examination, the mean age of the patients was 30 (19–46) years. We traced all 58 patients (69 operated hips) for the clinical evaluation.

During the evaluation at follow-up, we used a questionnaire which included the Merle d'Aubigné (1970) scoring system and the Harris hip score (HHS) (Harris 1969, Calvert et al. 1987). The preoperative clinical and radiographic data were compared with the same data 1 and 3 years postoperatively and at the latest follow-up examination. In 1 patient, who received a total hip replacement 8 years after the index operation, the results of the examination directly before the total hip replacement were used to evaluate the end result.

For assessment of loss of correction, we used the preoperative radiographs, the radiographs taken 6 months postoperatively, and the most recent radiographs of the pelvis. Radiographs were excluded when the quotient of rotation of the pelvis, using Tönnis and Brunken's method (1968) and the index of pelvic tilt of the pelvis, using Ball and Kommenda's method (1968), were not within the normal values of 0.56–1.8 and 0.75–1.2, respectively. The following radiographic measurements were made: acetabular angle, using Sharp's method (1961), CE (center-edge) angle, using Wiberg's method (1939), the MP (migration percentage), using Reimers' method (1980), the width of the joint space (minimum joint space measured between the weight bearing acetabulum and the femoral head), and the severity of arthrosis, using Tönnis' method (1984). Grade 1 indicates an increase in sclerosis of the femoral head and the acetabular weight bearing zone, minimal reduction in the width of the joint space, and minimal osteophytes; grade 2, small degenerative cysts, increasing reduction in the joint width, and moderate loss of roundness of the femoral head; and grade 3, large cysts, severely reduced joint width, severe loss of roundness or pathological shape and/or necrosis of the femoral head.

Statistics

We did a survival analysis, using total hip arthroplasty or a Merle d'Aubigné score < 13 and/or a HHS < 71 as failure criteria. We used the Kaplan Meier method (JMP software, version 3.1.6.2, 1996, SAS Institute Inc., Cary, USA) and present the survival curves with 95% confidence intervals. The p-value for survival curves was determined with the Wilcoxon test. The correlations between the variables and their significance were calculated using the Pearson chi-square test, the Wilcoxon signed rank test, the Student's t-test, and the Kruskal-Wallis test.

Results

Complications and reoperations

In a 20-year-old male patient with an extremely dysplastic hip joint (CE angle –12°) and arthrosis grade 2, a distraction between the cranial and caudal segments of the pelvis in combination with loss of correction occurred when the blade was driven in with the hammer during the intertrochanteric osteotomy, which was performed immediately after SIO. Unfortunately, the surgeon was not aware of this complication and the preoperative CE angle of –12° was only corrected to –4°. As a result, union was delayed. This patient showed no noteworthy clinical improvement. Because of increasing arthrosis, a total hip replacement was performed 8 years after the index operation. Another patient had to undergo reoperation 2 weeks after the first operation because of a fall that dislocated of the osteotomy and caused a loss

Table 1. Pain score (n = 69 hips)

	Preoperatively	1 year post-operatively	At latest follow-up
No pain	3	7	5
Slight	4	23	22
Mild	9	34	30
Moderate	29	3	9
Marked	24	2	2
Disabled	0	0	1

Table 2. Range of movement (mean and range in degrees) (n = 69 hips)

	Preoperatively	At final review
Flexion	126 (100–145)	116 (80–140)
Extension	1 (–15–10)	1 (–5–10)
Abduction	41 (10–80)	34 (10–60)
Adduction	28 (10–65)	22 (2–40)
External rotation	37 (0–80)	32 (0–80)
Internal rotation	32 (0–85)	27 (0–90)

of the correction. The radiographic result after reoperation was satisfactory. 1 patient developed nonunion and also had to be reoperated on 8 months postoperatively. In 5 patients, a superficial seroma or infected hematoma needed revision. In 1 patient, an intertrochanteric derotation osteotomy was performed 3 months after the index SIO when the threaded Steinmann pins were removed.

In 1 patient, a marked insufficiency of the gluteus medius muscle obviously resulted from a lesion of the gluteus superior nerve. In another patient, a transitory weakness of the extensor group of muscles of the toes recovered within a few days. Postoperatively, 25 patients had dysesthesia along the distribution of the lateral femoral cutaneous nerve. In 20 patients, the dysesthesia disappeared within 1 year.

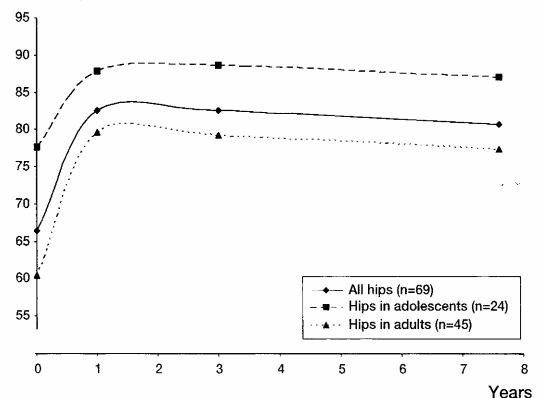


Figure 1. Graph showing the Harris hip score in relation to the length of follow-up. Both the adolescent and the adult groups improved in the first 2 years, but this was succeeded by a slow deterioration in the subsequent years.

Clinical evaluation (Tables 1–3)

At the latest follow-up, 29 patients were very satisfied with the result of the operation, 24 were satisfied, and 5 were not. Preoperatively, 4 of the 5 dissatisfied patients had had arthrosis grade 2, and 1 patient had had arthrosis grade 1. At the final review, all discontented patients had HHS < 71 points.

At the final review, flexion was less than before surgery(Wilcoxon signed rank test, $p < 0.0001$). In 13/19 adolescent and 34/45 adult hips, strength of the gluteus medius muscle was unchanged, in 11 adolescent and 5 adult hips, the limp improved and in 6 adult hips the limp became worse. Although the variations in gait were similar in the adolescents and adults before surgery (Pearson chi-square test, $p = 0.8$), at final review, the gait was worse in the adult group (Pearson chi-square test, $p = 0.02$).

Hip scores. Both the mean Harris hip and Merle d'Aubigné scores improved (Wilcoxon signed rank test, $p < 0.0001$), as compared to before surgery and at final review. We also found that the younger the patient at operation, the better the final hip score. The Harris hip score in relation to the length of follow-up in the adolescent and adult groups improved in the first 2 years and then slowly deteriorated subsequently (Figure 1). If one considers the mean hip score at final review, the result in the adolescent group (87, SD 9.8 points) was significantly better (Student's t test, $p = 0.0101$) than in the adult group (77, SD 17 points).

Radiographic evaluation (Table 4)

The CE angle improved from 11° preoperatively to 30° postoperatively. The mean correction of the CE angle was about the same in the adolescents (18°, SD 7.1°) as in the adults (20°, SD 19°). The radiographs about 6 months postoperatively showed a mean loss of correction of 0.9°. The radiographs at final review, as compared to the postoperative

Table 3. 69 hips of 58 patients treated with Salter's 1961) innominate osteotomy

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	1	F	36	L	5.0	13	47	28	4	2	2	53	63	SL	SL	1H	1H
2	2	F	16	R	7.0	12	30	31	14	1	0	83	96	N	N	2H	NL
3	3	F	35	R	4.5	7	34	36	21	1	1	67	83	SL	N	1H	2H
4	4	F	20	R	4.1	5	27	36	20	2	2	55	75	SL	SL	1H	1H
5	5	F	27	R	4.3	15	56	34	0	1	1	52	65	M	M	1H	2H
6	6	F	17	R	6.8	8	27	39	21	0	0	75	93	SL	N	1H	2H
7	7	F	35	R	10.2	9	20	42	29	1	1	57	75	SL	SL	1H	2H
8	8	M	23	R	11.3	20	29	23	13	1	1	60	93	N	N	1H	2H
9	9	F	28	R	4.6	14	32	33	20	1	1	67	90	SL	SL	1H	2H
10	9	F	29	L	4.0	12	28	38	20	1	1	67	90	SL	SL	1H	2H
11	10	M	15	R	7.4	7	18	41	29	1	1	70	81	SL	N	2H	2H
12	10	M	16	L	6.0	18	23	25	26	1	1	73	96	N	N	2H	2H
13	11	F	17	L	5.2	18	35	26	8	0	0	73	96	N	N	2H	NL
14	11	F	16	R	6.0	12	32	35	17	0	0	73	83	N	N	2H	NL
15	12	F	27	R	6.3	20	19	29	25	0	0	68	83	SL	SL	1H	NL
16	12	F	22	L	11.0	17	20	32	25	1	1	47	83	SL	SL	1H	NL
17	13	F	15	L	10.9	5	19	45	21	1	2	67	80	SL	SL	1H	2H
18	14	F	23	L	6.0	0	23	48	21	1	1	57	80	SL	SL	1H	2H
19	15	F	14	L	11.0	15	37	33	16	1	1	67	80	SL	SL	1H	2H
20	16	M	20	R	10.4	21	48	26	4	1	1	53	80	SL	SL	1H	2H
21	17	M	14	R	5.8	6	38	36	12	1	0	80	100	SL	N	2H	NL
22	18	F	26	L	10.6	11	31	39	11	1	1	48	64	SL	SL	1H	2H
23	19	F	13	R	6.4	5	31	40	14	0	0	97	97	SL	N	NL	2H
24	19	F	13	L	5.5	10	37	34	5	1	1	97	97	SL	N	NL	2H
25	20	F	18	R	4.7	7	37	42	20	1	2	50	76	M	M	1H	2H
26	21	M	13	R	9.7	17	44	29	4	1	1	97	93	SL	SL	NL	NL
27	22	F	14	L	9.4	7	25	40	25	1	1	67	83	M	N	2H	2H
28	23	F	22	R	10.9	6	25	33	11	1	1	70	90	SL	SL	2H	2H
29	23	F	21	L	12.1	11	25	31	21	1	1	70	90	SL	SL	2H	2H
30	24	F	36	R	3.8	-23	18	58	34	2	2	38	40	M	SL	ID	ID
31	25	F	17	R	8.7	-1	27	53	18	1	1	70	93	SL	N	2H	2H
32	26	F	18	R	6.7	17	31	30	16	1	1	67	80	SL	SL	1H	2H
33	26	F	19	L	5.8	15	37	27	12	1	1	77	90	SL	SL	1H	2H
34	27	F	23	R	6.4	21	38	24	15	0	0	67	97	SL	SL	1H	NL
35	27	F	22	L	7.6	10	31	37	16	1	1	57	93	SL	SL	1H	NL
36	28	F	35	R	7.5	14	21	28	34	2	2	42	62	M	M	ID	2H
37	29	F	28	R	6.8	9	36	32	6	1	1	86	93	N	N	NL	2H
38	29	F	29	L	6.0	14	29	29	19	0	0	96	97	N	N	NL	2H
39	30	F	25	L	6.8	3	17	39	27	1	1	50	77	M	M	ID	2H
40	31	F	35	L	5.9	0	25	47	24	0	0	83	96	N	N	2H	NL
41	32	F	19	L	7.8	8	40	40	27	1	1	68	83	N	N	1H	2H
42	33	F	35	R	10.3	6	16	42	37	2	2	47	53	M	M	ID	2H
43	34	M	37	L	7.0	12	24	31	27	1	1	57	93	SL	N	1H	2H
44	35	F	34	R	8.8	13	29	33	19	1	1	52	62	SL	SL	1H	1H
45	36	M	16	R	6.0	10	25	40	16	1	1	90	74	M	SL	NL	1H
46	36	M	17	L	5.2	12	19	36	27	1	1	90	74	M	SL	NL	1H
47	37	F	23	R	4.9	12	35	30	15	1	1	49	78	SL	SL	ID	2H
48	37	F	24	L	3.9	19	31	27	12	1	1	49	78	SL	SL	ID	2H
49	38	F	29	R	7.8	9	25	41	29	1	1	57	90	SL	N	1H	2H
50	39	M	27	R	11.1	25	25	22	26	2	2	57	62	SL	M	1H	1H
51	40	M	16	R	6.3	8	33	36	15	0	0	80	93	SL	N	2H	2H
52	41	M	15	L	10.3	22	31	17	15	1	1	80	96	SL	N	2H	NL
53	42	F	15	L	7.5	12	31	31	11	0	1	67	90	SL	SL	1H	2H
54	43	F	21	L	10.8	14	27	36	21	1	1	52	93	M	N	1H	2H
55	44	M	18	R	8.7	11	24	35	21	1	1	83	83	SL	SL	NL	NL
56	45	F	27	R	5.4	23	38	27	8	1	1	67	62	SL	M	1H	1H
57	46	F	21	R	4.0	-5	26	55	33	1	1	54	67	SL	SL	ID	1H
58	47	F	23	R	6.9	21	23	29	27	1	1	68	66	SL	SL	2H	2H
59	48	M	15	R	11.7	10	28	39	20	1	1	67	80	SL	SL	1H	2H
60	49	F	23	R	11.0	14	27	32	21	1	0	65	75	SL	SL	1H	1H
61	50	F	24	L	11.0	13	31	36	17	1	1	67	76	SL	M	1H	2H
62	51	M	26	R	8.6	15	26	28	17	1	1	70	80	SL	M	2H	NL
63	52	F	20	L	7.0	10	21	33	28	1	1	68	80	SL	SL	2H	2H
64	53	F	23	R	7.1	10	39	38	17	1	1	52	80	SL	M	ID	NL
65	54	M	19	R	3.9	12	33	38	19	1	1	67	80	SL	SL	1H	2H
66	55	F	19	L	8.7	15	21	35	29	2	2	66	76	SL	SL	1H	2H
67	56	F	17	L	11.8	28	30	27	6	1	1	90	90	SL	SL	2H	2H
68	57	F	16	R	9.6	-17	-36	65	67	2	2	60	60	M	M	1H	1H
69	58	M	20	R	10.8	-12	-16	70	61	2	2	51	0	M	SE	ID	ID

Table 3. Abbreviations

A	Hip number	N	Harris hip score at latest follow-up
B	Patient number	O	Preoperative limp
C	Gender		N no limp
D	Age at operation (years)		SL slight limp
E	Side of involvement		M moderate limp
F	Follow-up, years		SE severe limp
G	Preoperative CE angle	P	Limp at latest follow-up
H	CE angle at latest follow-up	Q	Preoperative walking ability
I	Preoperative MP (migration percentage)		NL no limitation
J	MP at last review		2H 2 hours
K	Preoperative grade of arthrosis		1H 1 hour
L	Grade of arthrosis at latest follow-up		ID only indoor activities
M	Preoperative Harris hip score	R	Walking ability at latest follow-up

radiographs, showed a mean deterioration in the CE angle of 2°. In a few cases with lateralization of the femoral head due to increasing arthrosis, the CE angle deteriorated up to 23°. Shenton's line, which had been considered disrupted in 39 of 69 hips before SIO, at the latest review was considered disrupted in only 3 hips (Pearson chi-square test, $p < 0.0001$).

Preoperatively, the mean width of the joint space of the 69 hips was 5.1 (SD 1.2) mm (98% of the unoperated side). 1 year postoperatively, the joint space was 4.8 (SD 1.2) mm, and at the latest follow-up examination, 4.7 (SD 1.2) mm (97% of the unoperated side).

Before the operation, 10 hips were classified as having no arthrosis, 50 as grade 1, and 9 as grade 2 arthrosis. At the latest follow-up examination, we found a radiographic improvement of one grade in 3 hips (all from grade 1 to grade 0). In 3 hips, we observed a deterioration of 1 grade (grade 1 to grade 2: 2; grade 0 to grade 1: 1).

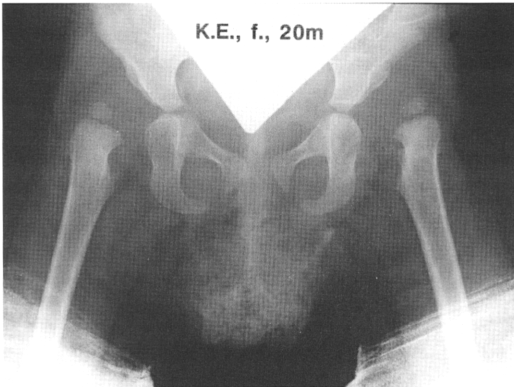
Correlations of radiographic data and clinical outcome. The grade of preoperative arthrosis affected both the preoperative (Kruskal-Wallis test, $p = 0.0002$) and postoperative (Kruskal-Wallis test, $p < 0.0001$) HHS. Before surgery, in hips without arthrosis ($n = 10$), the mean HHS improved from 78 (SD 11) points to 93 (SD 5.5) points at final review; in hips with coxarthrosis grade 1 ($n = 50$), it improved from 67 (SD 13) points to 83 (SD 9.8) points, while in hips with coxarthrosis grade 2 ($n = 9$), the score improved only from 52 (SD 8.8) to 55 (SD 23) points. The probability of failure was defined as total hip arthroplasty and a Merle

Table 4. Radiographic measurements before the innominate osteotomy, postoperatively and at latest follow-up

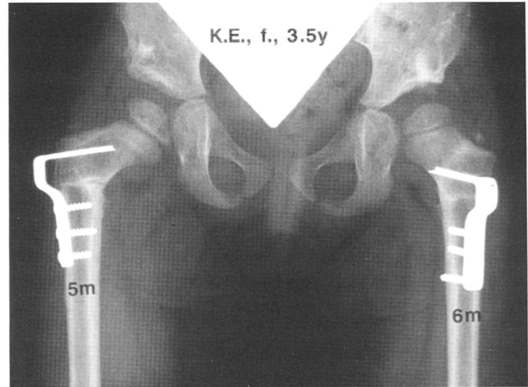
Group	Preoperatively mean (range)	Postoperatively mean (range)	Final review mean (range)	Mean individual change: preoperatively to final review (95% CI for mean)	P-value [a]
CE angle (degrees)					
Adolescents	11 (–17 to 28)	28 (–13 to 44)	29 (–36 to 44)	16 (12 to 21)	
Adults	11 (–23 to 25)	30 (–4 to 48)	28 (–16 to 56)	18 (15 to 21)	
All patients	11 (–23 to 28)	30 (–13 to 48)	28 (–36 to 56)	17 (15 to 20)	<0.0001
Acetabular angle, using Sharp's (1961)method (degrees)					
Adolescents	49 (18 to 58)	38 (30 to 44)	37 (29 to 44)	–12 (–15 to –8)	
Adults	48 (39 to 55)	35 (24 to 50)	36 (23 to 47)	–12 (–14 to –10)	
All patients	48 (18 to 58)	35 (24 to 50)	37 (23 to 47)	–12 (–13 to –10)	<0.0001
Migration percentage (%)					
Adolescents	36 (17 to 65)	16 (2 to 41)	19 (4 to 67)	–18 (–21 to –14)	
Adults	35 (22 to 70)	16 (2 to 56)	21 (0 to 61)	–15 (–17 to –12)	
All patients	36 (17 to 70)	16 (2 to 56)	20 (0 to 67)	–16 (–18 to –13)	<0.0001

[a] Wilcoxon signed rank test
Adolescents n = 24 hips, Adults n = 45 hips, All patients n = 69 hips, 95% CI = 95% confidence interval

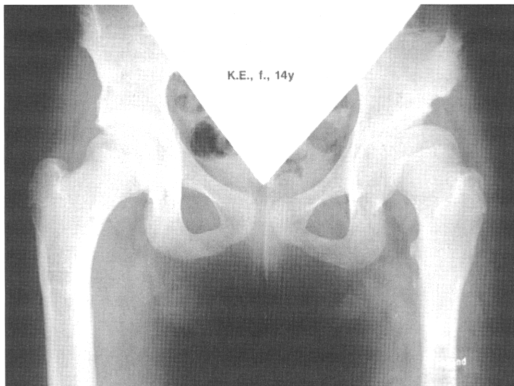
Figure 2. Girl, patient no. 22.



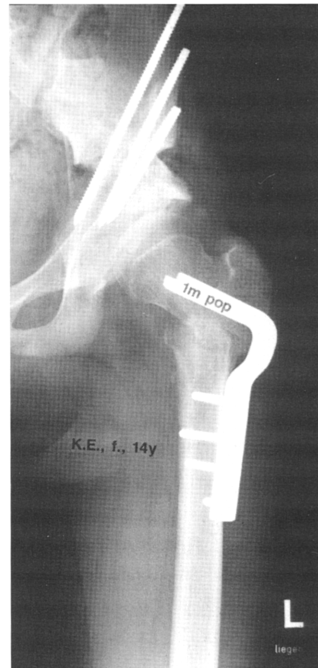
a. At the age of 20 months, bilateral congenital hip dislocation was diagnosed. After preoperative skin traction, open reduction, using the Ludloff technique, was performed.



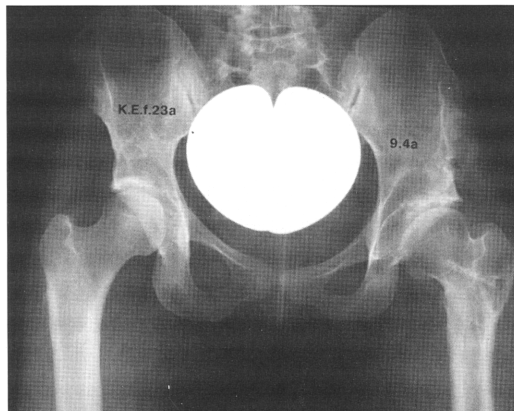
b. At the age of 3.5 years and about 6 months after Lance acetabuloplasty combined with intertrochanteric derotation and varisation osteotomy both hips are stable with good coverage of the femoral heads.



c. At the age of 14 years, she had increasing pain in her left hip. The right hip had become normal, but the left hip was abnormal with subluxation of the deformed femoral head. Signs of early arthrosis with degenerative cysts are present.



d. After SIO and varization osteotomy, definite improvement has occured, as regards coverage of the femoral head.



e. At the latest follow-up examination, 9 years after SIO, the patient had no pain and the HHS had improved from 67 preoperatively to 83 points. Despite the deformity of the femoral head with pathological congruence and loss of roundness and pathological shape, the hip still showed no signs of advanced arthrosis.

d'Aubigné score < 13 and/or HHS < 1) correlated with the grade of preoperative arthrosis (Pearson chi-square test, $p < 0.0001$) and was 0% in grade 0, 12% in grade 1, and 78% in grade 2.

Survival analysis

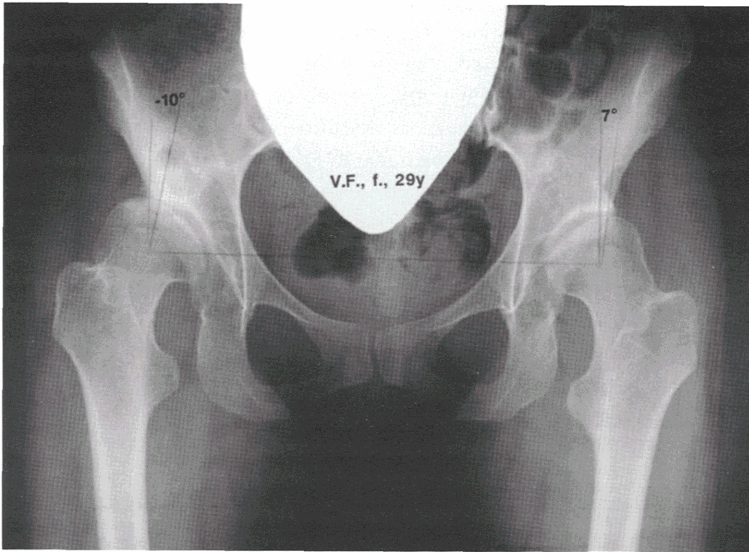
Moreover, apart from the only total hip arthroplasty, all cases with a Merle d'Aubigné score < 13 and/or a HHS < 71 were defined as failure. Using this definition, there were 13 failures. In 6 cases, the preoperative HHS was below 70 and was never higher than 70. To define the time of failure more exactly in the other 7 cases it was assumed that the HHS declined linearly between the latest follow-up, when the HHS was greater than 70, and the follow-up, when the HHS was 70 or less. Using this definition, the cumulative survival was 0.79 (95% CI, 0.69–0.89) at 12 years. There was a statistically significant effect of the preoperative grade of coxarthrosis on cumulative survival. Preoperatively, 6 of the 13 failed hips had had arthrosis grade 1, and 7 had had arthrosis grade 2. All 13 hips that failed had had a HHS of 70 or less preoperatively. Hips with severer dysplasia tended to have a lower cumulative survival, but the difference in the preoperative CE angle was not significant (Wilcoxon test, $p = 0.08$).

Discussion

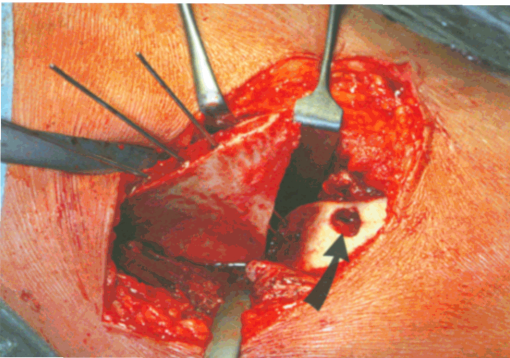
The surgical treatment of DDH is based on two assumptions: 1) that dysplasia and subluxation of the hip leads to arthrosis and 2) that improvement in the mechanics of the joint will slow down or even arrest the degeneration of the joint. In adolescents and adults with DDH, the indication and timing of surgical procedures are difficult, especially in those who are asymptomatic. Some authors report that one can not predict how long a patient with DDH will be pain-free from degenerative joint disease (Sutherland and Greenfield 1977). Others state that the age of onset of symptoms and of degenerative joint disease are related to the amount of subluxation and dysplasia (Tönnis et al. 1979, Weinstein 1987). The difference in tolerance of articular cartilage against pathological mechanics may explain the difficulty in predicting the onset of pain and arthrosis in patients younger than 30 years of age. In older patients, the correlation between amount of dysplasia and symptoms may be better. In our patients, the preoperative severity of dysplasia did not correlate with the amount of arthrosis, but the postoperative degree of dysplasia was related to the grade of coxarthrosis at final review. In patients having pain due to DDH who are good candidates for acetabular reorientation surgery, according to the recommendations of Salter et al. (1984), the operation should be performed as soon as possible, at least before severe arthrosis has developed. Like others (Salter et al. 1984, Lack et al. 1991), we found better clinical results in younger patients than in older ones.

The ideal amount of correction is one of the most widely discussed questions in surgical therapy of DDH in adolescents and young adults. There is no doubt that triple osteotomies, spherical osteotomies or periacetabular osteotomies can produce greater corrections than the SIO. However, a large correction angle of a severe dysplasia resulting in a normal CE angle may be an overcorrection because the acetabular roof of a dysplastic hip is shorter than a normal one. We should realize that after correcting the CE angle to normal, the resulting force will not be transferred from the head of the femur to the articular (lunate) surface of the acetabulum, but to the acetabular fossa. Leitz and Reck (1979) had very poor results after triple osteotomy, despite an ideal indication. They found that the result of triple osteotomy became progressively worse the more the acetabular fossa was brought into the zone of high pressure. According to Tönnis et al. (1994), a CE angle between 30° and 35° and a migration percentage between 10% and 15% gave the best pain relief. However, there is a risk of overcorrection. In our outpatient clinic, we saw patients who had rapidly developed severe arthrosis within a few months after triple osteotomy, with overcorrection of a slightly pathological acetabulum. Kotz et al. (1992) reported excellent short-term results with the polygonal triple osteotomy, but in 8 of 12 cases, the postoperative CE angle exceeded that recommended by Tönnis et al. (1994). In personal communications, the problem of overcorrection after triple osteotomies or periacetabular osteotomies is often discussed. In some articles, however, this important complication may not be adequately considered. In our series, the amount of

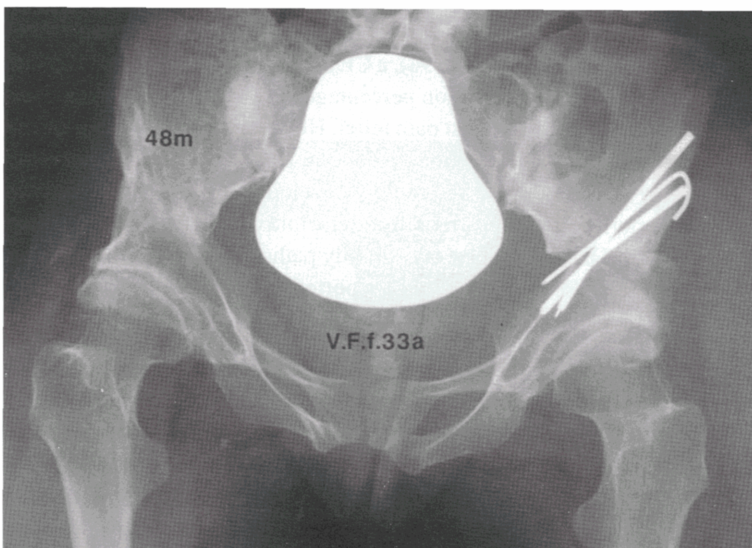
Figure 3. A 29-year-old female patient with a subluxated right hip (patient no. 38).



a. Note coxarthrosis grade 2 with a large supraacetabular degenerative cyst. The patient had marked pain with serious limitations of her activities. Despite the limited prospects of a good long-term result, SIO was indicated as a salvage procedure.



b. The intraoperative situation after osteotomy and correction, but before implantation of the bone graft, shows the large degenerative cyst (black arrow), which was curetted and the white sclerotic bone.



c. 4 years after surgery, there is now complete coverage of the femoral head and radiographically, the degenerative joint disease has clearly improved. The large cyst has disappeared. Meanwhile, the left hip has also been operated on because of increasing pain. The right hip is nearly pain-free. The patient has a full-time job as waitress in a restaurant.

correction of the CE angle (mean 17°) was similar to that achieved by Salter et al. (1984), using the SIO (mean 18°) and by de Kleuver et al. (1997), using the Tönnis triple osteotomy (mean 19°), but Trousdale et al. (1995) and Kotz et al. (1992) used a correction of 32° and 28°, respectively, in their patients. Due to the anatomic changes, the amount of correction in our series was limited.

26 of 59 hips with an extremely pathological or severely pathological CE angle before the operation finally had a normal one. At final review, 26 had a slightly pathological, 6 a severely pathological, and 1 an extremely pathological CE angle. The greater loss of movement of about 22° loss of flexion and internal rotation reported after polygonal triple osteotomy (Kotz et al. 1992), as compared to 10° loss of flexion and 7° loss of abduction in our series may have been caused by excessive correction.

There seems to be no advantage concerning the amount of correction of the double innominate osteotomy, as compared to the SIO (Sutherland and Moore 1991). With the exception of the polygonal triple osteotomy with a postoperative CE angle of 38°, the postoperative CE angle in most series is between about 24° and 31°, whatever the technique used for pelvic reorientation osteotomy.

Regardless of the technique employed for an osteotomy, severe preoperative arthrosis is associated with worse clinical results (Kerschbaumer and Bauer 1979, Migaud et al. 1995, Trousdale et al. 1995, de Kleuver et al. 1997, Hulet et al. 1998). Therefore, one of the most relevant predictors of the clinical mid-term result after acetabular reorientation surgery is the grade of preoperative arthrosis. Like other reports (Salter et al. 1984, Trousdale et al. 1995, de Kleuver et al. 1997), the results in our series were very encouraging for the patients with or without mild degenerative joint disease. In patients with grade 2 arthrosis (Figure 3), the pros and cons should be weighed before undertaking acetabular reorientation surgery because once arthrosis grade 2 has developed, the joint disease will probably increase even if operative correction is performed (Tönnis 1984, Salter et al. 1984). Most patients with grade 3 arthrosis or incongruence of the joint may not be good candidates for pelvic osteotomy (Salter et al. 1984, Trousdale et al. 1995, de Kleuver et al. 1997).

After a mean follow-up of between 4 and 10 years, the more complex osteotomies did not have a better clinical outcome or true revision rate than the SIO (Sutherland and Moore 1991, Kotz et al. 1992, Trousdale et al. 1995, de Kleuver et al. 1997). Since the SIO is a well standardized and simple operation with little risk of complications, we continue to prefer this operation also in adolescents and young adults.

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