

CLINICAL STUDY

Chiari pelvic osteotomy in the management of developmental hip dysplasia: a long term follow-up

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Purpose of the study. Developmental hip dysplasia in adults causes several anatomical changes which can lead to premature and progressive secondary osteoarthritis. The principle of Chiari osteotomy is the medialisation of the subluxated femoral head. This improves the biomechanics of the hip. The goal of the study was to assess the long term results of Chiari innominate osteotomy.

Material. The authors evaluated 130 hips after Chiari osteotomy from 230 patients operated on in the years 1969–1985 at the Ist Orthopaedic Department of St. Anna University Hospital in Brno, Czech Republic. The mean follow-up was 22.3 years (15–30) and there were 125 women and 5 men. The average age at the time of the procedure was 29 years (15–52).

Methods. We assessed the Harris hip score, daily activities, the length of the improvement after the procedure and asked the patients if they would undergo again the same procedure. We also assessed the CE angle, the Sharp angle, AHI index, the CCD angle, the Shenton's line, Crowe type of dysplasia, the shape of the femoral head and Kellgren – Lawrence grades of the osteoarthritis. There were 5 types of hip dysplasia in the study: coxa valga subluxans, coxa valga luxans, coxa plana brevis, coxa magna and severe deformity of the femoral head. There were 26 cases of hip dysplasia alone, 87 cases of hip dysplasia with a subluxation of the femoral head and 13 cases of dysplasia with a false acetabulum. We searched for the factors influencing the end results. We measured the medial shift of the distal pelvic fragment and the level of the osteotomy.

Results. The mean medial shift of the distal fragment was 22 mm e.g. 48.6 %. There was a correct level of the osteotomy in 113 patients. Radiological features improved: the CE angle (-12° to $+37.2^\circ$), the Sharp angle (48° to 41°), AHI index (51 to 96.3 %). The Harris hip score improved from 42 points to 67.5 points an average. 65 patients have been satisfied with the procedure, 49 were partially satisfied and 16 were not satisfied.

There were 80 patients without any other procedure (the first group) and there were 50 patients with the conversion to total hip replacement at the time of the latest follow-up (the second group). The mean age at the time of the operation was 24.2 years in the first group and 33.7 years in the second group. 62 patients in the first group had no osteoarthritis or grade 1 osteoarthritis at the time of the operation. 43 patients in the second group had grade 2 or 3 osteoarthritis at the time of the operation. The favourable results of the operation lasted 17.6 years in the first group and 11.1 years in the second group. The time between Chiari osteotomy and the conversion to total hip replacement was 12.2 years in the second group.

Discussion. The favourable factors are the age up to 30 years, no osteoarthritis or the grade 1 of osteoarthritis, coxa valga subluxans of Crowe type I and type II of hip dysplasia with a normal Shenton line, the spherical and ovoid shape of the femoral head, the correct level of the osteotomy and full coverage of the femoral head (medial shift 40 %).

The unfavourable factors for long term results were older age (over 35 years) of the patient at the time of the operation, grade 2 and 3 of osteoarthritis, severe deformity of the femoral head, Crowe type III of hip dysplasia with broken

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Shenton's line more than 20 mm, an angular shape of the femoral head, a CE angle below -15° , a high CCD angle (near to 180°) and incorrect procedure technique.

Conclusion. The study approved a favourable effect of Chiari pelvic osteotomy in patients with residual developmental hip dysplasia. The authors evaluated 130 patients operated on in the years 1969–1985 with a mean follow-up 22.3 years. In the first group (80 patients) a favourable result lasted an average of 17.6 years (3–30). 37 patients are still painfree, 35 patients have conservative treatment for osteoarthritis, 8 patients are planning a conversion to total hip replacement. Radiological signs have improved substantially. Harris hip score has improved from 42 points to 67.5 points on average. In the second group (50 patients) a favourable result lasted for average 11.1 years (0–29). All of them had a conversion to total hip replacement at the average of 12.2 years.

Chiari osteotomy gives the patients with residual developmental hip dysplasia and a correct indication favourable long-term results. It diminishes pain, prevents further subluxation and reduces the development of secondary osteoarthritis of the hip joint. (Tab. 6, Ref. 23.)

Key words: Chiari pelvic osteotomy, management of developmental hip dysplasia, hip joint.

Developmental hip dysplasia in adults causes several anatomical changes. They are a shelf, steep acetabulum with an insufficient superolateral and anterolateral coverage of the femoral head, a subluxation of the femoral head with lateralisation and proximal shift of the femur, a distorted shape of the femoral head, an insufficiency of the pelvifemoral muscles and changes of the shape and position of the proximal femur. One of the procedures which solves these anatomical changes at the site of the acetabulum is an osteotomy of the pelvis proposed by Karl Chiari (5, 6). Its principle is a medialisation of the subluxated femoral head. This improves biomechanics of the hip, adds an additional load-bearing surface and diminishes the stress of the articular cartilage of the hip. The goal of our study is to assess long term results of Chiari innominate osteotomy.

Material and methods

230 Chiari pelvic osteotomies have been performed for developmental hip dysplasia in the 1st Orthopaedic Department of St. Anna university Hospital in Brno, Czech Republic, in the years 1969–1985. We were able to obtain follow-up on 130 patients. There were 125 women and 5 men in our study. The mean age at the time of the operation was 29 years (15–52), and the mean follow up was 22.3 years (15–30 years).

We have assessed the Harris hip score, radiological appearance and results of a questionnaire. The questionnaire involved all items of the Harris hip score (pain, length of the gait, limping, crutches, climbing on stairs, sitting, shoes, getting into the bus, range of movement, contractures) (3), shortening of the leg, daily activities (well, with difficulties, with the assistance), assessment by the patient (satisfied, partially satisfied, not satisfied), working ability and the length of the improvement after the procedure. We asked the patients if they would undergo again the same procedure or if they recommend it to another patient. There were additional procedures performed with Chiari osteotomy in the study: valgus osteotomy of the femur 4, varus osteotomy of the femur 3, osteotomy of greater trochanter 3.

We assessed following radiological features: CE angle, Sharp angle, AHI index, CCD angle, Shenton's line, Crowe type of dysplasia, shape of the femoral head (spheric, ovoid, angular) and Kellgren–Lawrence grades of the osteoarthritis (OA). There

were 5 types of hip dysplasia in the study: coxa valga subluxans, coxa valga luxans, coxa plana brevis, coxa magna and severe deformity of the femoral head. There were 26 cases of hip dysplasia alone, 87 cases of hip dysplasia with a subluxation of the femoral head and 13 cases of dysplasia with a false acetabulum. We searched for the factors influencing the end results. We have measured the medial shift of the distal pelvic fragment:

b/a.100,

b is the distance between the inner contour of the distal and proximal fragments after the osteotomy, a is the distance of the width of os ilium just over the acetabulum. The ideal medial shift is 40 % (usually 20–25 mm) (14). We measured the height of the line of the osteotomy: correct 0–5 mm above the margin of the acetabulum, high – more than 5 mm above the margin of the acetabulum, low – intraarticular level.

The mean Harris hip score before the operation was 42 points (36–55). The degree of dysplasia was Crowe type I 95, Crowe type II 26 and Crowe type III 9 patients. The type of hip dysplasia was coxa valga subluxans 82, coxa valga luxans 14, coxa plana brevis 17, coxa magna 6 and severe deformity of the femoral head 11 patients. There were 56 patients without an osteoarthritis (OA), grade 1 in 30, grade 2 in 34, grade 3 in 5 and grade 4 in 5 patients. The spherical shape of the femoral head was in 17, the ovoid shape in 63, the angular shape in 39 and severe deformity of the head in 11 patients. Shenton's line was normal in 39, the breakage of the Shenton's line 1–10 mm in 40, the breakage of the Shenton's line 11–15 mm in 25 and the breakage of the Shenton's line above 16mm in 26 patients. The mean CE angle before the operation was -12° (-33° to $+16^\circ$), the mean Sharp angle was 48° (41° to $+16^\circ$) and the mean AHI index was 51 % (22–75).

Technique of the operation

The principle is an osteotomy of the iliac bone just above the acetabulum, a medial and dorsal shift of the distal fragment at the site of the symphysis (5, 6, 19). We use a supine position on a traction table and the Smith–Petersen approach I. We reflect caput reflexum of rectus femoris at the site of the junction of the joint capsule with the edge of the acetabulum. We checked the level of the osteotomy by the imagine intensifier. We performed

Tab. 1. The age at the time of the operation, the first group.

Age (years)	Patients
15-20	18
21-25	25
26-40	31
Over 40	6

Tab. 2. Harris Hip score, the first group.

Points	Patients
91-100	12
81-90	13
71-80	11
61-70	14
51-60	14
41-50	12
30-40	4

a curved osteotomy with an osteotome along the insertion of the joint capsule. The direction of the osteotomy is from the lateral margin of the acetabulum (below spina iliaca anterior inferior) to the sciatic notch at an 10° angle medially and proximally. We have used the Gigli saw only in an obese patients for the medial third of the osteotomy. Chiari and Reynolds did not use the Gigli saw at all. After finishing the osteotomy we released the traction of the leg and performed a full abduction. In that way we achieve the medialisation of the distal fragment of the pelvis. We used instrument leverage for shifting of the distal fragment of the pelvis medially and posteriorly. Thereafter the proximal fragment covered fully the subluxated femoral head laterally and anteriorly. Usually it is necessary to shift the distal fragment 2 to 3 centimeters. We made sure that the fragments of the osteotomy were in full contact. We stabilize the leg in 30° abduction. We used a suction drainage. We apply a hip spica cast for 4 weeks. After 4 weeks we started physiotherapy (exercise at the bed and walking on crutches without weightbearing). We allow full weightbearing after 3 months. We exercised intensively pelvi-femoral muscles.

Results

The mean medial shift of the distal fragment of the osteotomy was 21 mm or 48.6 % (21–75 %). We achieved a very good medialisation in 22, good in 97 and small medialisation in 8 patients. An extreme medial shift with no contact between fragments (overlapping) happened in 3 patients in which an open reduction was required. The proper level of the osteotomy was achieved in 113 patients, a high level in 9 and a low level in 3. The mean CE angle at the latest follow up was 37.2° (+15° to +58°), the mean Sharp angle was 41° (30°–53°) and the mean AHI index was 96.3 % (59–115).

65 patients were satisfied, 49 partially satisfied and 16 were not satisfied with the outcome. There were two groups of pa-

Tab. 3. The period of the favourable effect of the operation, the first group.

The favourable effect (years)	Patients
3-10	18
11-20	28
21-30	34

Tab. 4. The age at the time of the operation, the second group.

Age (years)	Patients
15-20	2
21-25	8
26-40	27
Over 40	13

tients in our follow-up study. The first group involved 80 patients. These patients did not undergo after Chiari osteotomy any another procedure. The second group involved 50 patients in whom conversion to total hip replacement was performed.

The mean age at the time of the operation in first group was 24.2 years. Only 6 patients were older than 40 years (Tab. 1).

62 patients from the first group had grade 1 of OA or were preosteoarthritic, 18 had the grade 2 and 3. The mean body mass index before the operation was 26.0 points. The mean Harris hip score at late follow-up was 67.5 points (Tab. 2).

A favourable result of the operation lasted 17.6 years (3–30) on the average. 37 patients were doing very well at the latest follow-up and do not need any other treatment, 35 patients had some conservative treatment for secondary osteoarthritis, 8 patients were planning a conversion to total hip replacement (Tab. 3).

The cause of worsening in the first group was the high level of the osteotomy in 2, grade 2 or 3 of OA in 3, low level of the osteotomy in one and the small medialisation of the distal fragment in 3 patients. One case of overlapping of the fragments required a revision. Overall, the end result was good.

The mean age in the second group was 33.7 years at the time of the operation. 13 patients were over 40 years of age (Tab. 4).

7 patients were at the time of the operation without OA or had grade 1 of OA, 43 patients had grade 2 or 3. The mean body mass index before the operation was 26.1 points. The favourable results lasted 11.1 years (0–29) on average (Tab. 5).

The mean period between Chiari osteotomy and the total hip replacement was 12.2 years (5–21). The mean Harris hip score with total hip replacement at the time of the latest follow-up was 75.0 points.

The cause of worsening after Chiari osteotomy in the second group was a high level of the osteotomy in 7, a low level of the osteotomy in 2, a small medialisation in 5, grade 2 or 3 of OA in 15, severe deformity of the femoral head in 11, coxa valga luxans with Crowe type III dysplasia with broken Shenton line more than 20 mm in 10, angular deformity of the femoral head in 2, CCD angle 180° in 2 and the nonunion in 2 patients. Extreme medialisation with no contact between the fragments (overlap-

ping) requiring a revision occurred in 2 patients. The revision did not influence the end result.

67 patients from 80 in the first group and 32 patients from 50 in the second group would agree to perform this procedure again and would recommend it to other patients (Tab. 6).

Discussion

There is an insufficient superolateral and anterolateral coverage and support of the femoral head in developmental hip dysplasia. There is a small load bearing surface between the head and the acetabulum. This creates a predisposition for premature and progressive degenerative changes of the hyaline cartilage of the hip joint. Karl Chiari published his procedure in 1953 and the first results in 1955 (5). The principle of the procedure is the medial shift of the femoral head covered by the joint capsule with the medial displacement of the distal fragment of the hemipelvis. The distal part of the hemipelvis rolls medially and posteriorly in symphysis. In this way a full coverage of the subluxated femoral head laterally and anteriorly is established. The procedure adds additional surface of real support for the femoral head. The medial shift of the distal part of the hemipelvis makes the load-bearing surface larger and reduces the stress on the articular cartilage. The medialisation should be 2 to 3 centimeters. The shift of 2 centimeters diminishes the stress of the femoral head by about 13 % (16). The lever of the abductor muscles is longer and the lever of the body weight is shorter (6, 16). The surface of the proximal fragment of the osteotomy has to be as near as possible to the articular capsule. The enlarged new acetabulum supports and covers the femoral head fully and prevents further subluxation.

Chiari (6) thought that a trabecular bone of the proximal fragment of the osteotomy will be remodeled to the surface of the thick joint capsule over the femoral head. The femoral head is inside the physiological joint capsule. Granulation tissue between the capsule and the trabecular bone of the proximal fragment transforms into ossifications and adapts to the surface of the joint capsule. In that way a new congruency is established.

Chiari determined the following indications for his osteotomy: 1. Coxa valga subluxans, 2. Congenital dislocation, 3. Coxa magna after Perthes' disease, 4. Paralytic hip in poliomyelitis or cerebral palsy, 5. Dysplastic hip with osteoarthritis.

We can state from our results that the outcome of Chiari osteotomy is influenced predominantly by the age of the patient at the time of the operation, by the grade of OA, by the anatomic deformity of the femoral head and by the technique of the procedure. The favourable factors are age up to 30 years, no OA or grade 1 of OA, coxa valga subluxans of Crowe type I and type II of hip dysplasia with a normal Shenton line, the spherical and ovoid shape of the femoral head, the correct level of the osteotomy and full coverage of the femoral head (medial shift 40 %).

The unfavourable factors for long term results are an older age (over 35 years) of the patient at the time of the operation, grade 2 and 3 of OA, severe deformity of the femoral head like coxa plana brevis, a condition after necrosis of the femoral head

Tab. 5. The period of the favourable effect of the operation, the second group.

The favourable effect (years)	Patients
0-10	24
11-20	20
21-30	6

Tab. 6. The recommendation for Chiari operation by the patients.

	Yes	Not sure	No
Group 1	67	9	4
Group 2	32	7	11

with high level of the greater trochanter, Crowe type III of hip dysplasia with broken Shenton's line and an angular shape of the femoral head, a high CCD angle up to 180° and a low CE angle (below -15°). Our results correspond with the results of Rejholec et al (18), who achieved better results in patients with a CE angle above -9°. They had worse results in cases with the high CCD angle (coxa valga).

We cannot anticipate good long term results if there is a small shift of the fragments of the hemipelvis, if the femoral head subluxation remains after the operation, in cases with the high level of the osteotomy, or if the osteotomy is directed from lateral side medially and distally instead medially and proximally. The other cause of a poor result was an intraarticular level of the osteotomy and nonunion. The cause of 3 revisions in our study was an extreme medialisation with no contact between the fragments.

Windhager et al (22) from the Orthopaedic University Clinic in Wiena published the end results after Chiari osteotomy in 236 hips in 208 patients operated on in the years 1953–1967. Most operations were performed by Karl Chiari himself. The mean age at the time of the operation was 14.1 years (3–51). The mean follow-up was 24.8 years. 90 % of the patients had severe hip dysplasia. They achieved very good and good results in 51.4 %, satisfactory results in 29.8 % and bad results in 18.3 %. The relief of pain lasted on average 17 years and was still present at the latest follow-up in 53.5 % of the patients. 19 patients had a conversion to total hip replacement and 2 patients had a conversion to the arthrodesis at the latest follow-up. The end results were getting worse with time. AO developed in 90 % of patients which did not have any radiological changes at the time of the operation. AO at the time of the operation was the cause of bad results and was progressive by that time. The intertrochanteric osteotomy performed at the same time did not improve the end result. Windhager et al recommends Chiari osteotomy in early adult age at the time of early complaints to relieve the pain in the hip joint. He emphasizes a full coverage of the subluxated femoral head.

Ohashi et al (12) published the results of 103 Chiari osteotomies in 91 patients from 126 operated on in the years 1956–1987. There were 86 hips in the first group with no OA or initial OA with the mean age at the time of the operation 18.2 years (6–48). 62 hips had Chiari osteotomy only, 24 hips had Chiari os-

teotomy with an intertrochanteric osteotomy. The mean follow up was 17.1 years. There were 17 hips in the second group with advanced OA. The mean age at the time of the operation was 36.8 years and the mean follow-up was 16.2 years. The mean JOA score (maximum 100 points) in the first group improved from 78 to 89 points. The mean time of survival of favourable results was 26 years. 33 % of the patients developed an advanced stage of OA. One patient had a conversion to total hip after 26 years. The CE angle improved from -4.4° to 29.4° . The progression of OA was smaller if the stage of hip dysplasia was smaller and CE angle was positive. They considered the ideal medial displacement to be 40–60 % and postoperative CE angle as $30\text{--}40^\circ$. Negative factors for the end result were a higher degree of OA and a low level of the osteotomy. There was an improvement of the JOA score from 63 to 84 points in the second group. 4 patients had a conversion to total hip replacement. The survivalship of Chiari osteotomy to conversion to total hip replacement was 72 % during 20 years. Chiari osteotomy brings favourable radiological results up to 25 years. They improved the shape of the femoral head and of the level of the osteotomy onto the end results.

The hips with a spherical and ovoid shape of the femoral head have better results in our study. Reynolds (19) achieved good results in hips with spherical and ovoid femoral heads. Ohashi et al (14) achieved better results after Chiari osteotomy in hips with spherical and angular shapes of the femoral head. In more than half of the patients with the ovoid shape of the femoral head and no OA did not have progression of osteoarthritis at the latest follow-up.

Reynolds (19) mentioned that Chiari osteotomy is not technically difficult, but it is safe and less demanding than the complex double or triple pelvic osteotomies. He states that Chiari osteotomy is indicated in hip dysplasia with irreparable subluxation. He emphasized that Chiari osteotomy is successful in spherical and ovoid femoral heads. It is not suitable for hips with marked breakage of Shenton's line more than 15 mm and in cases with lateral prominence of the femoral head. He uses the same approach as Chiari. He performs osteotomy with an osteotome not with the Gigli saw. The bone has to be cut as near as possible to the curve of the joint capsule. He recommends the direction of the osteotomy 10 degree from lateral side medially and proximally. If it is too distal, the displacement of the distal fragment is difficult, and if it is too proximal, the sacroiliac joint would be damaged and the osteotomy would be unstable. If the level of the osteotomy is at the correct level, the displacement of the distal fragment is done only by maximal abduction of the leg without any instrument leverage. Two centimeters shift of the distal fragment is enough. The osteotomy is stable in 30° of abduction. He does not use an internal fixation. After the operation he puts the patient on a traction of 3.5 kg for 3 weeks. Then he allows walking with crutches. He allows full weight bearing after 8–12 weeks.

Hulet et al (4) evaluated 53 Chiari osteotomies from the years 1974–1991 with a mean follow-up 10.5 years. They achieved a mean medial shift of 22 millimeters. 65 % of the patients had good results. 75 % of the patients were without pain at the last

follow-up. 15 patients had a conversion to total hip replacement. Factors for good long term results were age below 30 years, grade 1 or 2 of OA and a perfect operative technique. The favourable result cases with the grade 3 and 4 of OA lasted only up to 10 years. Chiari osteotomy is suitable for young patients with a painful, dysplastic hip with a low stage of osteoarthritis.

Mitchel (12) emphasized a perfect operative technique and use of the imagine intensifier for correct placement of the level and direction of the osteotomy. The osteotomy should be curved posteriorly to prevent a backwards slip of the distal fragment. It should be directed 10° medially and proximally. A osteotomy made too vertically in a narrow pelvis can be unstable and can cause damage to the sacroiliac joint. A horizontal direction of the osteotomy in a wide pelvis prevents a sufficient medial shift of the distal fragment. Valgosity and anteversion should be corrected before the osteotomy. He prefers Salter osteotomy in patients under 20 years of age if it possible to cover fully the subluxated femoral head.

Rott (20) published his experience with 86 Chiari osteotomies operated on in the years 1972–1977. He achieved favourable results if the Chiari osteotomy was performed in patients between 15–30 years of age, with no OA or with grade 1 of OA.

Migaud et al (11) evaluated 90 Chiari osteotomies in 83 patients at the average 6 years (2–15) after the procedure. 35 hips were painfree, 38 patients had slight pain, and 17 patients had a severe pain. Functional results were better in patients under 40 years of age and with advanced stage of hip dysplasia. Nevertheless two thirds of the patients over 40 years of age at the time of the procedure were doing well.

Some authors criticize the Chiari osteotomy for a worsening of limping and the Trendelenburg sign (13). Reynolds (19) did not find in his 32 patients operated at the age of 18–55 years any worsening of preoperative limping. 7 patients with a positive preoperative Trendelenburg sign have improved fully and 13 significantly. In our first group of 80 patients the limping continued in 48 but did not worsen in any of them. The Trendelenburg sign remained positive in all 48 patients. Windhager found the same incidence of Trendelenburg sign before and after the operation. He found in patients operated on before 7 years of age a slight improvement.

We have countered following complications in our study: secondary healing of the wound in 2, deep infection in 1, small medialisation in 8, overlapping of fragments requiring a revision in 3, nonunion in 2, transient peroneal palsy in 1, meralgia paresthetica in 1, and flebotrombosis in 6. After the introduction of prevention for flebotrombosis with low molecular heparin we did not see any. Windhager (22) found in his series of 236 hips with Chiari osteotomy following complications: peroneal palsy in 2, transient meralgia paresthetica in 1, deep infection in 2, secondary healing of the wound in 2, heterotopic ossifications in 1, small medialisation requiring a revision in 3. Ohashi (13) found in his study of 103 Chiari osteotomies one case of damage of external iliac artery requiring an anastomosis. They solved a nonunion of the same patient with bone grafting 9 months later.

Rott (20) found in 3 patients with grade 3 OA an osteonecrosis of the femoral head in the part covered by the osteotomy. The previously not supported part of the head came into a direct contact with a new shelf. The increased pressure led to a progressive deformation of the femoral head. Ohashi (14) found one case of osteonecrosis in the proximolateral part of the ovoid femoral head in a 13-year old boy.

Ohzono et al (15) called attention to labral lesions in secondary postdysplastic osteoarthritis. They performed arthrography and classified the labrum as normal, torn or detached. They performed 64 modified Chiari osteotomies in the years 1978–1983. Preoperative arthrography has shown labral lesions in 66 %. The patients with a normal or torn labrum had very good or good results. The patients with the detached labrum had bad results. They combined Chiari osteotomy with an arthrotomy in 16 patients in the years 1984–1989. They removed a detached labral lesion. Their results were good in grade 1 and 2 OA and were satisfactory in grade 3 OA.

Koyama et al (8) evaluated 13 patients with 14 Chiari innominate osteotomies for Perthes disease. The mean age at the time of the operation was 33 (16–56) years. The mean follow-up was 6 years (2–12). The mean Harris hip score has improved from 71 points to 91 points. Radiological signs (CE angle, Sharp angle, AHI index) have improved significantly. He recommends Chiari osteotomy in a painful postdysplastic osteoarthritis of the hip joint in young adults.

The advantage of a double or triple innominate osteotomy is in covering and supporting of the femoral head by a hyaline cartilage. De Kleuver (7) with triple innominate osteotomy in 48 hips achieved favourable results in 39 with follow-up of 8 to 15 years. He had 29 (60 %) very good and good results. He found a progression of OA in 21 % of the patients after 10 years. Trousdale (24) found a reduction of OA in 52 % after triple pelvic osteotomy. The disadvantage of the triple pelvic osteotomy is a lateralisation of the femoral head. Dungal (2) found lateralisation in one of his 8 patients in a follow-up study of 8–30 months. He emphasized that Steel triple osteotomy is a demanding procedure. The Trendelenburg sign became negative in all 8 patients and limping improved in 7 of them. The prerequisite for a good result after Steel osteotomy is a distalisation of the femoral head to the level of the acetabulum and a centric position of the head in the acetabulum. On the other hand Tönnis left the femoral head before the Steel osteotomy in a neocotyl. In that way he improved the covering of the femoral head and improved conditions for total hip arthroplasty.

Poul and Vejrostova (17) emphasized that the end result of the pelvic osteotomy depends on the severity of hip dysplasia. They evaluated 29 Steel triple pelvis osteotomies 4–12 years after the operation. They achieved favourable results in 19 patients either in cases with a insufficiency of the acetabulum and a spherical shape of the femoral head or in cases of a subluxation with a spherical femoral head. They found in cases with a deformity of the femoral head with a defect of the coverage (aspherical congruency) and in cases with a subluxation and with a deformity of the femoral head (aspherical incongruency) a partial

improvement in 7 and no improvement in 2 out of 10 cases. The better the improvement of the CE angle and the Sharp angle, the better the end result. They achieved favourable results in 11 of 12 patients in Perthes' disease operated on at the age of 9–12 years.

Mellerowicz et al (10) created a new scoring system involving subjective and objective items for the evaluation of surgical procedures. According to their evaluation system the Salter osteotomy ensured a long term relief of pain and enabled a normal development of the hip. Chiari osteotomy is indicated in patients over 15 years of age. Chiari osteotomy cannot significantly prevent development of osteoarthritis. The long term results of both osteotomies are dependent on the initial stage of hip dysplasia. Additional procedures on the proximal femur do not influence the further development of the hip.

McCarthy et al (9) evaluated 31 hips in 28 patients operated on for a painful acetabular dysplasia by Salter osteotomy at the average age of 22 years. The mean follow-up was 71 months. 21 patients have been satisfied with the result and would recommend the procedure to the others. The Harris hip score has improved on average from 71.2 points to 88.3 points. The acetabular angle decreased by 10°, the CE angle by 13.2°, and the AHI index by 15 %. They had 6 complications: nonunion in 1, deep infection in 1, heterotopic ossifications in 1, and meralgia paresthetica in 3. They performed one Chiari osteotomy and a conversion to total hip replacement in 2 patients in unsuccessful cases. According to his experience, the Salter osteotomy gives good results and improves the radiological features of the dysplastic hip.

The indications for a shelf procedure or a Chiari osteotomy are not firmly established. The shelf procedure is curative in cases of a simple acetabular dysplasia with a defect of the lateral margin of the acetabulum without lateralisation, in cases with the CE angle slightly under 20° and the Sharp angle slightly under 37°. We perform the shelf procedure in cases in which there is a lateral defect of the acetabulum and in cases of aspherical congruency with slight lateralisation (angular deformity of the femoral head), the CE angle 0–20°, no OA or the grade I of OA and at the age 14–25 years. The Shelf procedure remains a palliative procedure in cases in which the femoral head is in the lateral position. We indicate Chiari osteotomy if the defect of the acetabulum is more in anterior part, in cases of spherical congruency with marked lateralisation, with the CE angle low or negative, at the age 14–40 years. We prefer Salter osteotomy in cases of hip dysplasia in patients under 15.

Nishimatsu et al (13) evaluated the results of 119 hips after the Spitzzy shelf procedure at a mean follow up of 23.8 years. They found better results in patients operated on under the age of 25 years with prearthrosis or an initial stage of OA than in patients operated on over the age of 25 years with a marked OA (80.3/100 versus 68.2/100 according JOA score). They found an improvement of the CE angle (-0.01° versus 40.3°), an improvement of the Sharp angle (52.3° versus 39.4°) and of AHI index (48.8 % versus 89.7 %). The important factor in the end result is the level of the shelf (distance between the graft and the lateral

margin of the acetabulum). The tectum should not be too low or too high. He emphasized that Spitzzy procedure has less complications than the Chiari pelvic osteotomy.

Our study showed a favourable effect of the Chiari pelvis osteotomy in patients with residual developmental hip dysplasia. We have evaluated 130 patients operated on in the years 1969–1985 at a mean follow-up 22.3 years. In the first group (80 patients) a favourable result lasted an average 17.6 years (3–30). 37 patients were painfree, 35 patients had conservative treatment for osteoarthritis, and 8 patients are planning a conversion to total hip replacement. Radiological signs have improved substantially: the CE angle (-12° to $+37^{\circ}$), the Sharp angle (48° to 41°) and the AHI index (51 to 96.3 %). The Harris hip score has improved from 42 points to 67.5 points an average. In the second group (50 patients) a favourable result lasted an average of 11.1 years (0–29). All of them had a conversion to total hip replacement an average of 12.2 years.

The favourable results are seen in patients aged up to 30 years, with no OA or the grade 1 of OA, coxa valga subluxans of Crowe I or II type, the normal Shenton's line, the spherical or ovoid shape of the femoral head, the correct level of the osteotomy and the full coverage of the head after the procedure (medialisation at least 40 %).

Chiari osteotomy gives patients with the residual developmental hip dysplasia in a correct indication favourable long term results. It diminishes the pain, prevents a further subluxation and reduces the development of secondary osteoarthritis of the hip joint.

References

1. Calvert PT, August AC, Albert JS, Kemp HB, Caterall A. The Chiari pelvic osteotomy: a review of the long term results. *J Bone Jt Surg* 1987; 69-B: 551–555.
2. Dungal P, Slavik M. Prvni zkusenosti s troji panevni osteotomii podle Steela. *Acta Chir Ortop Traum Cech* 1985; 52: 303–315.
3. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures by mold arthroplasty. An end-results study using a new method of result evaluation. *J Bone Jt Surg* 1969; 51-A: 737–755.
4. Hulet C, Schiltz D, Vielpeau C, Locker B, Richter D, Aubriot JH. Incidence of arthrosis in the results of the treatment of coxarthrosis in the young adult with Chiari osteotomy. *Rev Chir Ortop Repair Appair Moteur* 1998; 84 (1): 41–50.
5. Chiari K. Ergebnisse mit der Beckenosteotomie als Pfannendachplastik. *Z Orthop* 1955; 87: 14–26.
6. Chiari K. Medial Displacement Osteotomy of the Pelvis. *Clin Orthop* 1974; 98: 55–71.
7. De Kleuver M, Kooijman MAP, Pavlov PW, Veth RPH. Triple osteotomy of the pelvis for acetabular dysplasia. *J Bone Joint Surg* 1997; 79-B: 225–229.
8. Koyama K, Higuchi F, Inoue A. Modified Chiari osteotomy for arthrosis after Perthes' disease. 14 hips followed for 2–12 years. *Acta Orthop Scand* 1998; 69 (2): 129–132.
9. McCarthy JJ, Fox JS, Gurd AR. Innominate osteotomy in adolescent and adults who have acetabular dysplasia. *J Bone Joint Surg* 1998; 80 (2): 301–302.
10. Mellerowicz HH, Matussek J, Baum C. Long-term results of Salter and Chiari osteotomies in developmental hip dysplasia. A survey of over 10 years follow-up with a new hip evaluation score. *Arch Ortop Trauma Surg (Germ)* 1998; 117 (4–5): 222–227.
11. Migaud H, Duquennoy A, Gougeon F, Fontaine C, Pasquier G. Outcome of Chiari pelvis osteotomy in adults. *Acta Orthop Scand (Norway)* 1995; 66: 127–131.
12. Mitchell GP. Chiari medial displacement osteotomy. *Clin Orthop* 1974; 98: 146–150.
13. Nishimatsu H, Iida H, Kawanabe K, Tamura J, Nakamura T. The modified Spitzzy shelf operation for patients with dysplasia of the hip. *J Bone Joint Surg* 2002; 84-B: 647–652.
14. Ohashi H, Hirohashi K, Yamano Y. Factors influencing the outcome of Chiari pelvis osteotomy: a long term follow up. *J Bone Joint Surg* 2000; 82-B: 517–525.
15. Ohzono K, Sakai T, Haraguchi K, Lee K, Matsui M, Sugano N, Nishii T, Ochi T. The Osaka concept dome osteotomy with or without labrum resection. *Der Orthopaed* 1998; 27 (11): 759–764.
16. Pauwels F. Atlas zur Biomechanik der gesunden und kranken Hüfte. Prinzipien, Technik und Resultate einer kausalen Therapie. Berlin—Heidelberg—New York, Springer Verlag 1973.
17. Poul J, Vejrostova M. Trojita osteotomie panve u deti a adolescentu. *Acta Chir Orthop Traum Cech* 2001; 68: 93–98.
18. Rejholec M, Stryhal F, Rybka V, Popelka S. Chiari osteotomy of the pelvis: a long term study. *J Pediat Orthop* 1990; 10: 21–27.
19. Reynolds DA. Chiari innominate osteotomy in adults. Technique, indications and contraindications. *J Bone Joint Surg* 1986; 68-B: 45–54.
20. Rott Z. Uskali operace podle Chiari. *Acta Chir Orthop Traum Cech* 1983; 50: 248–254.
21. Rozkydal Z, Smid Z. Plastika strisky acetabula podle Bothwortha — dlouhodobé výsledky. *Acta Chir Ortop Traum Cech* 1991; 58: 20–27.
22. Windhager R, Pongracz N, Schönecker W, Kotz R. Chiari osteotomy for congenital dislocation and subluxion of the hip. *J Bone Joint Surg* 1991; 73-B: 890–895.
23. Tönnis D. Diagnose und Therapie der Hüftdysplasie des Alteren Kindes. *Z Orthop* 1990; 128: 369–372.
24. Trousdale RT, Ekkernkamp A, Ganz R, Wallrichs SL. Periacetabular and intertrochanteric osteotomy for the treatment of osteoarthritis in dysplastic hips. *J Bone Joint Surg* 1995; 77-A: 73–85.

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