Periacetabular osteotomy

Good pain relief in symptomatic hip dysplasia, 32 patients followed for 4 years

Francesco Pogliacomi[1], André Stark[2] and Richard Wallensten[2]

[1]Section of Orthopaedics, Traumatology and Functional Orthopaedic Rehabilitation, Department of Internal Medicine and Biomedical Sciences, University of Parma, Parma Hospital, Via Gramsci 14, IT-43100 Parma, Italy, [2]Department of Orthopaedics, Karolinska Hospital (Karolinska Institute), SE-171 76 Stockholm, Sweden
Correspondence RW: richard.wallensten@ks.se
Submitted 03-04-10. Accepted 04-03-03

Background **When surgical treatment of dysplastic hip osteoarthrosis is necessary, osteotomy is preferable to fusion or THR. We evaluated periacetabular osteotomy as a method of choice.**

Patients and methods **We treated 36 symptomatic dysplastic hip joints (32 patients) with the Bernese periacetabular osteotomy (PAO) between 1994 and 2001. We used the ilio-inguinal (I-I) approach in 32 hips and a modified Smith-Petersen (S-P) approach in 4. The patients were followed for mean 4 (1.5–8) years. In 1 patient with coxa valga, a varus femoral osteotomy was performed 1 year after PAO. 2 hips, in which we used the modified S-P approach, necessitated a capsulotomy.**

Results **The median Merle d'Aubignè score increased from 13 points preoperatively to 16 points postoperatively. This improvement in terms of pain, motion and ambulation was accompanied by spatial reorientation and correction. The lateral center edge angle of Wiberg (CE) improved from an average of 7° to 28°. The anterior center edge angle of Lequesne (FP) improved from an average of 18° to 28°. The acetabular index angle (AC) improved from an average of 22° to 10°.**

Major complications included 1 partial lesion of the sciatic nerve, 1 malunion and 1 combined nonunion of the pubic and ischiatic osteotomy. 2 patients underwent subsequent total hip replacement (THR) for progressive osteoarthrosis with pain.

Interpretation **We found good radiographic correction of deformities, improvement of hip function and pain relief with an acceptable complication rate. With appropriate patient selection, this procedure is the most physiological treatment of symptomatic hip dysplasia in young adults. In addition to relieving symptoms, it may prevent and postpone the development of secondary osteoarthrosis.**

The natural course of events in untreated congenital hip dysplasia and developmental hip dysplasia (DDH) is the development of secondary osteoarthrosis (Cooperman et al. 1983, Aronson 1986). Although THR is an excellent treatment in elderly and sedentary patients with end-stage arthrosis, the results in younger, more active patients are controversial and variable (Chandler et al. 1981, Berry and Cabanela 1993, Callaghan 1994, Callaghan et al. 1997, Sharp et al. 2000).

Since the problem is on the acetabular side, the most physiological solution for young adults is to correct the deficient and malorientated coverage of the femoral head and to restore the mechanics of the hip. This can be obtained by periacetabular osteotomy, which augments and reorientates the acetabulum. There are a number of different pelvic osteotomies that address hip dysplasia (Chiari 1953, Salter 1961, LeCour 1965, Steel 1973, Eppright 1975, Wagner 1976, Sutherland and Greenfield 1977, Tönnis et al. 1981, Ninomiya and Tagawa 1984).

The Bernese PAO was developed in 1983 and was first described by Ganz et al. (1988). This is a polygon-shaped juxtaarticular osteotomy (Figure

DOI 10.1080/00016470510030346

Figure 1. Extent of osteotomy lines.

a. Inner aspect of the acetabulum.

b. Outer aspect of the acetabulum.

1) which may be performed through one single approach, where large corrections can be obtained in all directions without any external fixation since the posterior column of the ischium remains intact, protecting the sciatic nerve and permitting early mobilization. The diameter of the true pelvis remains intact, permitting unimpaired vaginal delivery (Flückiger et al. 2000). The blood supply to the acetabulum is preserved and this allows an anterior joint capsulotomy for diagnosis and treatment of intra-articular diseases.

Two surgical approaches have been used: the modified S-P approach (Mac Donald et al. 1997, Leunig et al. 2001) and the I-I approach (Letournel 1993). Most centers use the modified S-P approach because of the higher rate of vascular complications and the impossibility of performing a capsulotomy with the I-I approach (Hussell et al. 1999).

We evaluated our results in 32 patients operated on with the periacetabular osteotomy and with 16 months minimum follow-up time.

Patients and methods

Surgical procedure

The patients were operated on a standard table and image intensifier was used to control the level of the osteotomies and the reorientation of the acetabulum (Stark and Wallensten 2003). The surgical procedure consists of 5 osteotomies: 1) "incomplete ischiatic osteotomy", which starts at the infracotyloid groove incompletely separating the ischiatic bone. This passage is performed under direct vision and from the inside of the pelvis using the I-I approach; 2) complete osteotomy of the superior pubic ramus at its mid-point, beginning medial to the pectineal eminence and angled medially; 3) "supra-acetabular iliac osteotomy", extending through the ilium from a point between the anterior superior and anterior inferior iliac spines to a point 1 cm proximal to the pelvic brim and 3 cm anterior to the sacro-iliac joint; 4) "retro-acetabular iliac osteotomy", performed from the inside of the pelvis, extending along the posterior column from the endpoint of the supra-acetabular iliac osteotomy to a point 4 cm distant from the pelvic brim; 5) the last osteotomy connects the incomplete ischiatic osteotomy to the retro-acetabular osteotomy at a level 4 cm distal to and parallel to the pelvic brim.

Before the fifth step, a Schanz screw is inserted into the inferior anterior iliac spine parallel to the supra-acetabular osteotomy and this allows a good lever for mobilization of the fragment. The freed osteotomized acetabulum is then reoriented in ideal position and fixed with cortical screws. This position was decided on the basis of the preoperative radiographs. Our aim was to achieve a normal CE angle and FP angle. The position of the rotated acetabulum was controlled with fluoroscopy and using K-wires. The wires were placed parallel in two planes on both sides of the osteotomy. After rotating the fragment, the angles between the corresponding wires were measured and the result was checked on the image intensifier.

Postoperatively, the patients were kept in bed for 24 hours and on the second day after surgery, partial weight bearing with two crutches was started and continued for 8–10 weeks. Single-dose antibiotic prophylaxis with semisynthetic penicillin and antithrombotic prophylaxis with low molecular heparin was given to all patients. Discharge from hospital was usually after 7–10 days.

Patient selection

The operation is indicated in young patients with painful acetabular dysplasia and closed epiphyseal plates. Hip flexion should be more than 100°. The operation is contraindicated if there is a lack of congruency between the femoral head and the acetabulum, if there is complete dislocation with a secondary acetabulum or if there is an advanced osteoarthrosis (grade 3, Tönnis 1987).

The upper age limit is determined by the age at which total joint replacement can be expected to give good long-term results. The preoperative radiographs consist of a preoperative A-P projection with the hip in abduction of 20°–30° and a false profile view according to Lequesne and de Sèze (1985). CT scans or MRI were not performed preoperatively.

Patients and follow-up

Between 1994 and 2001, PAOs were performed in 32 patients (36 hips, 31 women) at the Orthopaedic Department of Karolinska Hospital, Stockholm. The median age of patients at surgery was 35 (15–55) years. Osteotomies were performed on the right hip in 12 patients, the left in 16 patients and bilaterally in 4 patients. All operations were performed by two of the authors (RW and AS). The I-I approach described by Letournel (Letournel 1993) was used in 32 hips and a modified S-P approach was used in 4 hips. In 7 patients (7 hips) previous attempts at surgical correction of the dysplastic hip joint had been performed (3 Salter osteotomy, 1 Salter osteotomy combined with varus femoral osteotomy and 3 varus femoral osteotomy).

The preoperative diagnosis was symptomatic hip dysplasia presenting with pain in 31 patients (35 hips) and symptomatic posttraumatic hip dysplasia in 1 patient (1 hip). This last patient was a man who had nonoperative treatment of an acetabular fracture at the age of 2 years. He developed a painful dysplastic hip with a retroverted acetabulum. In all patients, the degree of dysplasia was classified according to the criteria of Severin (1941). 22 joints represented dysplastic hips without subluxation of the femoral head (groups I, II, and III). 14 hips were classified as group IV with femoral head subluxation. There were no hips representing group V with a secondary acetabulum.

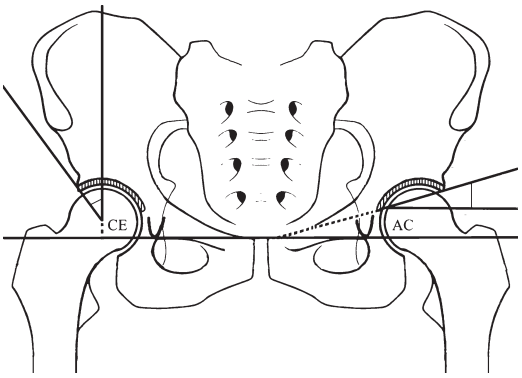

Figure 2. CE angle of Wiberg (right hip); angle formed by the perpendicular to the inter-tear drop line and the line from the center of the femoral head to the lateral edge of the sourcil. AC angle (left hip); angle formed by the line joining the medial and lateral edges of the sourcil and the line parallel to the inter-tear drop line.

The radiographic evaluations were done with a standard anteroposterior pelvis projection and a false profile view according to Lequesne and de Sèze (1985). Deficiency and correction of lateral and anterior coverage was measured by the angles described by Wiberg (centre edge angle) (Wiberg 1939) and the obliquity of the sourcil was evaluated by the AC angle (Figure 2). Deficiency and correction of anterior coverage was measured by the angles described by Lequesne de Sèze (1985) (FP angle). We also assessed Shenton's line (SL) integrity. Radiographic assessment was done preoperatively, postoperatively during the hospital stay, at 6–8 weeks, at 6 and 12 months after surgery, and then annually. Preoperatively, anteroposterior abduction radiographs were used to assess the joint congruency achievable with reorientation of the acetabulum. Presence and grade of osteoarthrosis was graded according to the criteria of Tönnis (1987). The radiographic severity of osteoarthrosis preoperatively was grade 0 in 18 hips, grade 1 in 9 hips, grade 2 in 7 hips and grade 3 in 2 hips.

Pain, ambulation and range of motion (ROM) was assessed preoperatively and at the latest follow-up using the scoring system of Merle D'Aubignè (MA score) (D'Aubigné and Postel 1954). All patients were asked how satisfied they were after the osteotomy.

The median follow-up was 4.1 (1.5–8) years.

Results

The median CE angle increased from 7° (-12°–32°) preoperatively to 28° (7°–52°) postoperatively. The FP angle averaged 18° (-8°–48°) preoperatively and improved to 28° (10°–60°) postoperatively. The AC angle decreased from a median of 22° (4°–40°) preoperatively to 10° (-4°–25°) postoperatively (Table 1).

The Shenton line was broken in 15 hips preoperatively, as compared to 3 hips (group IV of Severin) (1941) postoperatively. In 4 hips, a poor congruency between femoral head and acetabulum was present in the abduction projection preoperatively.

The median MA score improved from 13 (5–17) points preoperatively to 16 (7–18) points postoperatively. The median pain score improved from 3.0 (1–6) points preoperatively to 5.1 (2–6) points postoperatively. The median ROM score averaged 5.3 (5–6) preoperatively and 5.8 (5–6) postoperatively. The median ambulation score improved from 4.1 (1–6) preoperatively to 5 (1–6) postoperatively (Table 2).

The MA score was poor in 21 hips preoperatively, fair in 10, medium in 1, good in 3 and very good in 1. Postoperatively, the score was poor in 3 cases, fair in 2, medium in 4, good in 14 and very good in 13 (Table 3; Figure 3). The improved functional grading of the hip was accompanied by patient satisfaction in 29 out of 32 patients.

The operation time averaged 200 (110–420) min. Blood loss averaged 2.3 (0.8–6.9) L. We observed damage of the lateral femoral cutaneous nerve with a transitory palsy in half of the patients (18 cases). In 1 case, there was a partial lesion of the sciatic nerve with persistent severe pain in the leg but without loss of motor function, and this was treated with a spinal cord stimulator. There was no perioperative lesion of the large vessels and no thromboembolic complications in the postoperative period. In 1 patient, the screws were removed because of local problems and secondary displacement of the acetabular fragment.

Mean time to consolidation was 3 months. All osteotomies but one healed in the desired position. In the patient with the malpositioned osteotomy, a limping gate was present. In 1 case (inclination angle = 150°), a varus femoral osteotomy was performed 1 year after PAO. In 2 cases, operated through the S-P modified approach, we opened the hip joint to remove a ganglion. One patient who had a large acetabular reorientation developed a nonunion of the pubic and ischial osteotomy with pain. She had a new operation with a pubic plate and autologous bone graft. 2 patients were dissatisfied: the one with partial lesion of the sciatic nerve and nonunion of ischial and pubic osteotomy and the one with loss of the initial acetabular fixation. In 2 patients (3 hips) the pain returned after 5 and 7 years, respectively. Their osteoarthrosis was graded

Table 1. Radiographic evaluation

Parameter	Preoperative	Postoperative
CE angle (range)	7 (-12–32)°	28 (7–52)°
FP angle (range)	18 (-8–48)°	28 (10–60)°
AC angle (range)	22 (4–40)°	10 (-4–25)°
SL broken, n	15	3

Table 2. Clinical outcome (D'Aubigné and Postel 1954)

MA score	Preoperative	Postoperative
Total	13 (5–17)	16 (7–18)
Pain	3.0 (1–6)	5.1 (2–6)
ROM	5.3 (5–6)	5.8 (5–6)
Ambulation	4.1 (1–6)	5.0 (1–6)

Table 3. Functional outcome (d'Aubigné and Postel 1954)

	Preoperative	Postoperative
Poor	21	3
Fair	10	2
Medium	1	4
Good	3	14
Very good	1	13

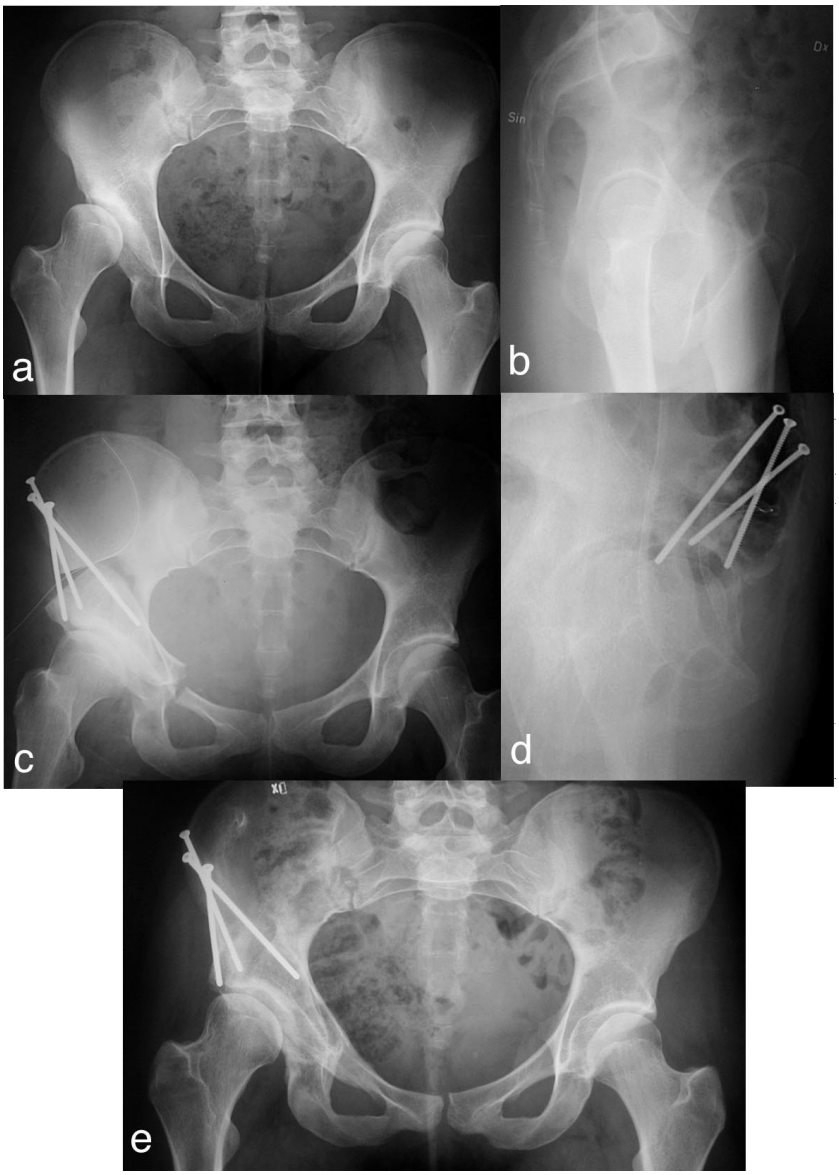

Figure 3. PAO through I-I approach in an 18-year-old woman with acetabular dysplasia (right side).
a. Preoperative AP projection.
b. Preoperative "false profile" projection.
c. Postoperative AP projection.
d. Postoperative "false profile" projection.
e. 1.5 years after the operation.

as Tönnis grade 3 in 2 hips and Tönnis grade 2 in 1 hip. The hips were converted to THR. In spite of this, the 2 patients were still satisfied with the 5 and 7 pain-free years achieved by the osteotomy.

Discussion

The periacetabular osteotomy has numerous advantages over other techniques (Ganz et al. 1988, Leunig et al. 2001). By reorienting the acetabulum one can achieve better coverage of the

femoral head, with improved load distribution in the hip and less pain.

Our findings regarding correction, complications and early functional outcomes indicate that the procedure is safe and that the results are predictable. The correction of the dysplasia as measured by the different angles corresponds well with the findings of other authors (Ganz et al. 1988, Trousdale et al. 1995, Siebenrock et al. 1999). In all patients a positive CE angle was achieved, which was the main goal. In 5 patients operated on during the first 2 years, a possible overcorrection (CE angle > 40º) happened, which we attribute to the learning curve. The AC angle was < 20º in all but 6 patients. There was no difference in the clinical outcome whether the AC angle was < 20° or not.

Reorientation of the acetabulum resulted in an improvement in the postoperative functional outcome, as shown by the increase in the average MA score (13 points preoperatively and 16 points postoperatively). This procedure resulted in less pain in the hip for the majority of patients. The MA score for pain increased from 3.0 to 5.1. As described by Van Bergayk and Garbuz (2002), the osteotomy often results in a decreased range of movement of the hip. In our experience, the range of motion was unaffected with a preoperative score of 5.3 and a postoperative score of 5.8, as was the ambulation with a preoperative score of 4.1 and postoperative score of 5.

A periacetabular osteotomy combines the advantages of long-term pain relief, preserved range of motion and (eventually) the possibility of total hip replacement. In the event of such an operation, the increased sphericity of the acetabulum after the osteotomy provides better fixation possibilities for the acetabular cup. Furthermore, Flückiger et al. (2000) have shown that the diameter of the true pelvis after surgery permits unimpaired vaginal delivery. The improved pain and functions scores were also accompanied by patient satisfaction; 29 of 32 patients were definitely satisfied with the outcome. This is in accordance with the results of other authors (Ganz et al. 1988, Mac Donald et al. 1997, Crockarell et al. 1999, Davey and Santore 1999, Matta et al. 1999, Trumble et al. 1999, Takatori 2001, Ganz and Leunig 2002).

The operation is technically difficult and has a definite learning curve. This is evident from our results where both operating time and degree of blood loss became reduced as more patients were operated. There were two complications related to technical errors. One patient had a partial injury to the sciatic nerve, probably because of incorrect placement of a retractor behind the posterior column. One patient had secondary displacement of the acetabular fragment due to insufficient screw fixation.

Damage to the lateral cutaneous femoral nerve was present after surgery in 18 of 36 cases. The anesthetic area decreased over time without any problems for the patients. These data contrast with and higher than the 35% of lateral femoral cutaneous nerve morbidity described by Letournel (1993) using the same approach, and the 30% of lateral femoral cutaneous nerve morbidity registered by Hussell et al. (1999) using the modified S-P approach. We have no explanation for this, as every effort was made to protect and preserve the nerve. Other authors (Ganz et al. 1988, MacDonald et al. 1997, Davey ad Santore 1999) have encountered serious problems such as necrosis of the acetabular fragment. We did not encounter this complication.

In 32 of 36 cases, we used the I-I approach (Letournel 1993, Macnicol 1996) because of the possibility of performing all osteotomies under direct vision and because the abductor muscles remain untouched. The I-I approach has been associated with a higher risk of serious vascular damage (Hussell et al. 1999). There were no intraoperative lesions of the large vessels and no thromboembolic complications using this approach.

The I-I technique does not allow an exploration of the hip joint. Several authors (Ganz and Leunig 2002, Millis et al. 1995, Millis and Murphy1998) have recommended that this should always be done, considering the high incidence of labral lesions. Such lesions are generally diagnosed on MRI but are not always accompanied by clinical symptoms, and their significance remains to be established. In patients with suspected or proven labrum pathology, an approach which allows arthrotomy should be used. We used the modified S-P incision in 4 patients. In 2 of them, it was necessary to open the hip joint and remove a ganglion. In patients with coxa valga/excessive anteversion in combination with dysplasia, a varus derotational femur osteotomy can be performed together with

the pelvic osteotomy—or at a later date (Trousdale et al. 1995). This is indicated if the femoral head is still lateralized after the rotation of the acetabulum and congruent with the acetabulum in abduction. In our series this was done only once.

The follow-up time in our patients was relatively short: mean 4.1 (maximum 8) years. A radiographic follow-up of possible progression of the osteoarthrosis was therefore considered to be of no interest. During that time, 2 of 32 patients (3 hips) have had deterioration of symptoms to the extent that total joint replacement was necessary. In retrospect, we feel that these patients may have had osteoarthosis that was too advanced (Tönnis grade 3) for a periacetabular osteotomy. However, this result is in accordance with reports by other authors (Ganz et al. 1988, MacDonald et al. 1997, Crockarell et al. 1999, Davey and Santore 1999, Matta et al. 1999, Trumble et al. 1999, Takatori 2001, Ganz and Leunig 2002). No technical problems were encountered in the 3 hips where a hip arthroplasty was performed.

We conclude that young adult patients with symptomatic dysplasia benefit from a periacetabular osteotomy, provided the hip is congruent. Good pain relief can be expected. Since the operation is technically advanced and the patient group small, the procedure should preferably be performed only in centers specializing in pelvic surgery. Long-term improvement is to be expected and in the event of conversion to a total hip arthroplasty, the improved acetabular coverage facilitates fixation of the acetabular cup.

Aronson J. Osteoarthritis of the young adult hip. Etiology and treatment. Instr Course Lect 1986; 35: 119-28.

Berry D J, Cabanela M E. Primary uncemented total hip arthroplasty in patients less than 40 years of age. Orthop Trans 1993; 17: 601.

Callaghan J J. Results of primary total hip arthroplasty in young patients. Instr Course Lect 1994; 43: 315-21.

Callaghan J J, Forest E E, Sporer S M, Goetz D D, Johnston R C. Total hip arthroplasty in the young adult. Clin Orthop 1997; (334): 257-62.

Chandler J P, Reineck F T, Wixson R L, Mc Carthy J C. Total hip replacement in patients younger than thirty years old. J Bone Joint Surg (Am) 1981; 63: 1426-34.

Chiari K. Beckenosteotomie zur Pfannen-dachplastik. Wien Med Wochenschr 1953; 103: 707-10.

Cooperman D R, Wallensten R, Stulberg S A. Acetabular dysplasia in the adult. Clin Orthop 1983; (175): 79-85.

Crockarell J, Trousdale R T, Cabanela M E, Berry D J. Early experience and results with the periacetabular osteotomy. Clin Orthop 1999; (363): 45-53.

D'Aubigne R M, Postel M. Hip arthroplasty with acrylic prosthesis. J Bone Joint Surg (Am) 1954; 36 (7): 451-75.

Davey J P, Santore R F. Complications of periacetabular osteotomy. Clin Orthop 1999; (363): 33-7.

Eppright R H. Dial osteotomy of the acetabulum in the treatment of dysplasia of the hip. J Bone Joint Surg (Am) 1975; 57 (8): 1172-??.

Flückiger G, Eggli S, Kosina J, Ganz R. Birth after periacetabular osteotomy. Orthopäde 2000; 29: 63-7.

Ganz R, Leunig M. Osteotomy and the dysplastic hip: the Bernese experience. Orthopaedics 2002; 25 (9): 945-6.

Ganz R, Klaue K, Vinh T S, Mast J. A new peri-acetabular osteotomy for the treatment of hip dysplasias. Clin Orthop 1988; (232): 26-36.

Hussell J G, Mast J W, Mayo K A, Howie D W, Ganz R. A comparison of different surgical approaches for the periacetabular osteotomy. Clin Orthop 1999; (363): 64-72.

LeCouer P. Corrections des default d'orientation de l'articulation coxo-femorale per l'osteotomie de l'isthme iliaque. Rev Chir Orthop Reparatrice Appar Mot 1965; 51: 211-5.

Lequesne M, de Sèze S. Le faux profile du bassin. Nouvelle incidence radiographique pour l'etude de la hanches. Son utilità dans les dysplasies et les differentes coxopathies. Rev Rheum Mal Osteoartic 1985; 28: 643-52.

Letournel E. The treatment of acetabular fractures through the ilioinguinal approach. Clin Orthop 1993; (292): 62-76.

Leunig M, Siebenrock K A, Ganz R. Rationale of periacetabular osteotomy and background work. J Bone Joint Surg (Am) 2001; 83 (3): 438-48.

MacDonald S J, Hersche O, Rodriguez J, Ganz R. The Bernese periacetabular osteotomy for the treatment of adult hip dysplasia. Chir Organi Mov 1997; 82 (2): 143-54.

Macnicol M F. Berne periacetabular osteotomy. In: Color atlas and text of osteotomy of the hip (Ed. Mosby-Wolfe), Barcelona 1996; 7: 51-70.

Matta M J, Stover M D, Siebenrock K. Periacetabular osteotomy through the S-P approach. Clin Orthop 1999; (363): 21-32.

Millis M B, Murphy S B. The Boston concept. Peri-acetabular osteotomy with simultaneous arthrotomy via direct anterior approach. Orthopäde 1998; 27: 751-8.

Millis M, Murphy S, Poss R. Osteotomies about the hip for the prevention and treatment of osteoarthrosis. J Bone Joint Surg (Am) 1995; 77 (4): 626-47.

Ninomiya S, Tagawa H. Rotational acetabular osteotomy for the dysplastic hip. J Bone Joint Surg (Am) 1984; 66 (3): 430-6.

Salter R B. Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. J Bone Joint Surg (Br) 1961; 43 (3): 518-39.

Severin E. Contribution to the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthrographic studies of recent cases. Acta Chir Scand (Suppl) 1941; 63: 53-4.

Sharp R J, O'Leary S T, Falworth M. Analysis of the results of the C-Fit uncemented total hip arthroplasty in young patients with hydroxyapatite or porous coating of components. J Arthroplasty 2000; 15: 627-34.

Siebenrock K A, Scholl E, Lottenbach M, Ganz R. Bernese periacetabular osteotomy. Clin Orthop 1999; (363): 9-20.

Stark A, Wallensten R. Periacetabular osteotomy using the ilioinguinal incision for treatment of hip dysplasia. Operat Orthop Taumatol 2003; 3: 269-87.

Steel H H. Triple osteotomy of the innominate bone. J Bone Joint Surg (Am) 1973; 55 (4): 343-50.

Sutherland D H, Greenfield R. Double innominate osteotomy. J Bone Joint Surg (Am) 1977; 59 (4): 1082-91.

Takatori Y. Bernese periacetabular osteotomy. Clin Orthop 2001; (387): 245-6.

Tönnis D. Congenital dysplasia and dislocation of the hip in children and adults. Springer-Verlag, Berlin 1987; 113-31, 165-71, 370-81.

Tönnis D, Behrens K, Tscharani F. A modified technique of the triple pelvic osteotomy: early results. J Pediatric Orthop 1981; 1: 241-9.

Trousdale R T, Ekkernkamp A, Ganz R, Wallrichs S L. Periacetabular and intertrochanteric osteotomy for the treatment of osteoarthrosis in dysplastic hip. J Bone Joint Surg (Am) 1995: 77 (1): 73-85.

Trumble S J. Mayo K A, Mast J W. The periacetabular osteotomy. Clin Orthop 1999; (363): 54-63.

Van Bergayk A B, Garbuz D S. Quality of life and sports-specific outcomes after Bernese periacetabular osteotomy. J Bone Joint Surg (Br) 2002; 84 (3): 339-43.

Wagner H. Osteotomies for congenital hip dislocation. In: The hip. Proceedings of the fourth open scientific meeting of the hip society. Mosby, St Louis 1976; 45-66.

Wiberg G. Studies on dysplastic acetabula and congenital subluxation of the hip joint with special reference to the complication of the osteoarthritis. Acta Chir Scand (Suppl 83) 1939; 58: 1-135.