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ORIGINAL ARTICLE

Periacetabular osteotomy of the hip: the ilioinguinal approach

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Abstract. Developmental hip dysplasia (DDH) is characterized by an anomalous growth of the hip joint. Without adequate treatment, the natural history of DDH is development of secondary osteoarthritis in adulthood. The correction of the deformities modifies the biomechanics of the hip, which is important in order to slow down the progression of osteoarthritis and maybe to prevent and postpone this development. The Bernese periacetabular osteotomy is a procedure which reorientates the acetabular articular surface. Several surgical approaches have been used to achieve the same effective osteotomy. No surgical approach represents "the optimum", with selection of appropriate exposure representing a balance of advantages and disadvantages. We used the ilioinguinal approach in 32 periacetabular osteotomies for acetabular dysplasia performed between 1996 and 2002. The operation was successful in 30 patients with acceptable operation time and blood loss and few complications. The advantages and disadvantages with the ilioinguinal approach as compared to other possibile incisions are discussed.

Key words: periacetabular osteotomy, acetabular dysplasia, reorientation osteotomies, ilioinguinal approach

Introduction

Developmental hip dysplasia (DDH) is characterized by an anomalous growth of the hip joint components and usually leads to joint incongruency (1).

Biomechanical abnormalities and residual joint deformities are present in dysplastic hips (2, 3, 4). Both the proximal part of the femur and the acetabulum are involved but there is an increasing body of evidence that the main problem is on the acetabular side (acetabular dysplasia) (5, 6); in the majority of patients there is a poor coverage of the superior and anterior part of the femoral head, a reduction of the femoral depth, excessive lateralization of the femoral head, an abnormal Wiberg angle, anterior centre edge angle and acetabular index.

These factors lead to a decreased surface contact area in the hip, with a subsequent increase in joint contact pressure.

Consequently the natural history of DDH is the development of degenerative secondary osteoarthritis. Cooperman (7) noted in his series of 32 patients with dysplastic hips a 66% incidence of severe osteoarthrosis after 22 years of follow-up. Stulberg and Harris (8) have shown that an evidence of primary acetabular dysplasia was present in 48% of their patients with degenerative joint disease.

The most physiologic solution, in order to slow down the progression and to prevent and postpone the development of secondary osteoarthritis in a young adult with acetabular dysplasia, is reorientation of the acetabulum into a more normal position and restoration of normal biomechanics.

Pelvic reorientation osteotomies change the spatial orientation of the acetabulum normalizing the antero-lateral coverage deficiency of the femoral head. Reorientation procedures include single (9), double (10) and triple innominate osteotomies (11-13), as well as spherical (14) and periacetabular osteotomies.

A new pelvic osteotomy, the Bernese periacetabular osteotomy (PAO), was developed by R. Ganz (15) in 1983. In this operation a large correction may be achieved in all directions through only one surgical approach, without dividing the posterior column of the pelvis, with preservation of the blood supply to the acetabular fragment and with the possibility to maintain the shape of the true pelvis intact (15, 16).

Five osteotomies has to be performed:

- complete osteotomy of the pubic ramus at its mid-point beginning medial to the pectineal eminence and angled medially
- "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
- "retro-acetabular iliac osteotomy" extending, along the posterior column, from the end point of the supra-acetabular iliac osteotomy to a point distant 4 cm from the pelvic brim
- "incomplete ischiatic osteotomy" which starts at the infracotyloid groove incompletely separating the ischiatic bone
- "fracture controlled osteotomy" which connects the incomplete ischiatic osteotomy to the retro-acetabular osteotomy at a level 4 cm distal to and parallel to the pelvic brim.

The osteotomized acetabulum is then reoriented and definitevely fixed with cortical screws.

For the Bernese PAO the Smith-Petersen (S-P), Smith-Petersen modified (S-P modified), ilioinguinal (I-I), direct anterior and double approach have been used (15, 17-19).

Until 1993 R. Ganz performed the PAO through a classic S-P approach which required extensive separation of the abductors and flexors from the iliac wing and spines.

Since 1993 (5, 20, 21) the same Author uses a modified S-P approach, in which the skin incision is similar to the classic but an osteotomy of the anterior superior iliac spine preserves the attachment of the sartorius muscle and the ilioinguinal ligament; the abductors are elevated from the iliac wing at the level of the horizontal part of the superior acetabular osteotomy with less stripping and damage of the muscles.

This approach allows capsulotomy of the hip joint and the acetabular fragment can be manipulated easier; the operating view is limited as compared to the I-I approach and the incomplete ischiatic osteotomy is not under direct vision but is a blind osteotomy which must be aided by image intensifier.

Some centers (16) utilize either the 2nd and 3rd window of the I-I approach and perform all the osteotomies from the inside of the pelvis under direct vision. With this surgical approach the abductor muscles remain untouched; this approach doesn't allow capsulotomy of the hip joint, the operating time is longer, the acetabular fragment is more difficult to manipulate and requires a large amount of medial retraction of the anterior neurovascular bundle with risks of arterial thrombosis.

There are three main differences in the surgical technique between PAO performed through S-P modified and I-I approach:

- "chronology" of the osteotomies
- incomplete ischiatic osteotomy (fig. 1)
- final fixation with screws (fig. 2).

The "chronology" of the osteotomies with modified S-P approach is the following: incomplete ischiatic osteotomy, complete osteotomy of the pubic ramus, supra-acetabular iliac osteotomy, retro-acetabular iliac osteotomy and "fracture controlled osteotomy" which connects the incomplete ischiatic osteotomy to the retro-acetabular osteotomy.

The "chronology" of the osteotomies with I-I approach is the following: complete osteotomy of the pubic ramus, supra-acetabular iliac osteotomy, retro-acetabular iliac osteotomy, incomplete ischiatic osteotomy, and "fracture controlled osteotomy" which connects the incomplete ischiatic osteotomy to the retro-acetabular osteotomy.

With S-P modified approach the incomplete ischiatic osteotomy is a blind osteotomy and performed from the outer pelvic wall. With the hip in flexion and after palpation of the ischium to determine its loca-

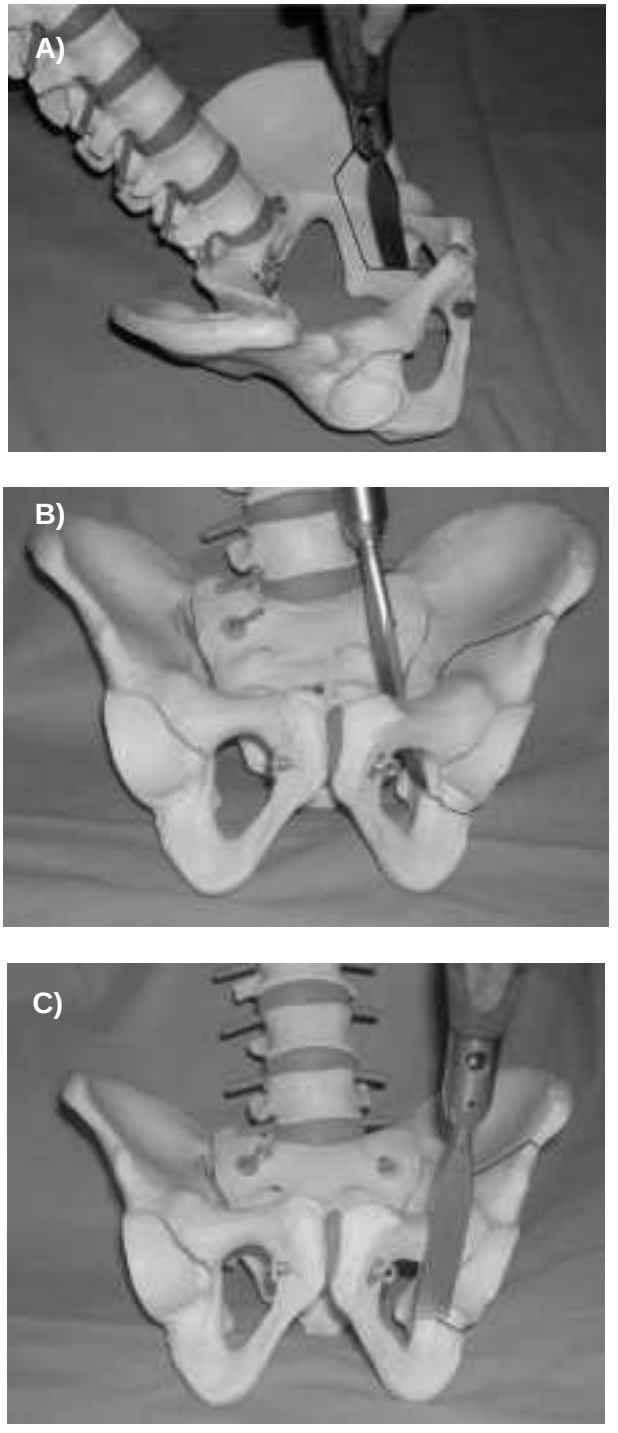

Figure 1. A, B; PAO through I-I approach; anterior edge of ischial osteotomy (incomplete ischiatic osteotomy) using the osteotome from the inner pelvic wall and through the window lateral to the psoas. C; PAO through S-P modified approach; anterior edge of ischial osteotony (incomplete ischiatic osteotomy) using the osteotome from the outer pelvic wall.

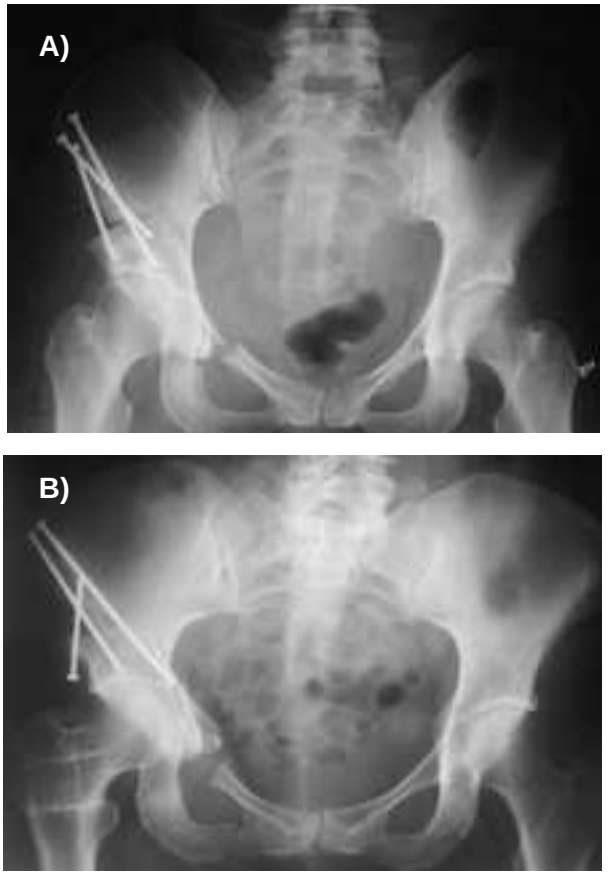

Figure 2. A; PAO through I-I approach and with the use of 3 screws from the iliac crest to the acetabulum. B; PAO through S-P modified approach with the use of 2 screws from the iliac crest to the acetabulum and 1 from the acetabulum to the iliac wing.

tion and size, a special angled osteotome is inserted distal to the acetabulum between the capsule and the tendon of the psoas and the obturator externus muscle. The incomplete separation of ischial bone starts at the infracotyloid groove with a depth of 15 to 25 mm.

With I-I approach the incomplete ischiatic osteotomy is performed under direct vision and from the inner pelvic wall. Through either the intermediate or lateral window, a special 35° angled osteotome is inserted inside the pelvis and placed on the anterior edge of the ischium in the foramen obturatorium. The curve of the osteotome is designed to lie at a distance of 4 cm from the cutting edge of the instrument. When the elbow of the instrument is at the level of the pelvic brim and the handle is perpendicular to the line of the pelvic

inlet, the correct position is reached and the osteotomy is performed; the osteotome is inserted 1 cm into the ischium until it stays unsupported in position.

The final fixation is obtained with cortical screws directed from the iliac crest to the acetabular fragment; through S-P modified approach another screw may be directed from the inferior iliac spine to the iliac wing.

The direct anterior approach and the double approach are less frequently used (15, 17, 19).

The direct anterior approach, described first by Millis in the early 1990's (15, 19), combines S-P modified and I-I approach; the tensor fasciae latae and abductor muscles can be left attached to the lateral aspect of the ilium and is similar to the S-P modified for manipulation of the fragment, access to intra-articular pathologic changes and speed. Skin cosmesis is better than that seen with S-P modified approach but, on the contrary, the dissection proceeds medial to the iliopsoas with lots of dangers for femoral nerve.

A double approach, introduced by Tonnis (13) for his triple osteotomy and adopted also for PAO, had the goal of minimizing particular difficulties with the blind ischial osteotomy. A postero-lateral approach is used to expose the ischium and this is the main disadvantage because it needs an additional 1,5 hours operating time including the repositioning.

Materials and methods

Between 1996 and March 2002 PAO was performed in 30 patients (32 hips). Two patients underwent bilateral PAO. The mean age of patients at surgery was 34,5 years (range, 15-51 years). The osteotomy was performed on 30 hips in females and on 2 hips in males.

In 5 patients previous attempts for surgical correction of the dysplastic hip joint had been performed (3 Salter osteotomy, 1 Salter osteotomy combined with varus femoral osteotomy and 1 varus femoral osteotomy).

The indication for surgery was symptomatic hip dysplasia presenting with pain in 31 cases and symptomatic post-traumatic hip dysplasia in 1 case.

The I-I approach described by Letournel (18, 16) was used in all these patients. The patient is in a supine position and the skin incision runs from the junction of the middle and posterior third of the iliac crest, crosses the superior anterior iliac spine and continues to the symphysis 2 cm proximal and along the inguinal ligament (fig. 3).

The external oblique fascia and the aponeurosis of the "obliquus externus" muscle are divided from the inguinal ligament taking care not to injure to the ilioinguinal nerve and round ligament or vas deferens.

The abdominal muscles origin are detached from the iliac crest and the mass of the iliopsoas muscle is detached from the inner pelvic wall by subperiosteal dissection.

The inguinal canal is incised in its entire length. The lateral 1/3 of the incision will reveal the iliopsoas muscle, upon which, longitudinally on its lateral aspect, the lateral femoral cutaneous nerve lays; on its antero-medial aspect the femoral nerve has its path. The lateral femoral cutaneous nerve is often injured even if handled with great care. A drain or vessel loop may be introduced around the muscle and nerves acting as protection.

The medial part of the incision will reveal the femoral artery and vein which are dissected in their path avoiding intimal tears in vessel's wall and taking care to the occasional anastomosis between femoral and obturatory artery (the so called "corona mortis"); another drain or loop can be introduced around the vessels.

Figure 3. I-I approach (left side); extent of skin incision.

The artery together with femoral vein in medial part of the incision and iliopsoas muscle together with nerves in lateral part of the incision delimit 3 windows (medial, intermediate and lateral) through which the surgeon may reach the bony structures and perform all the cuts (fig. 4).

After positioning of a blunt Hohmann retractor in the greater sciatic notch from the outside of the pelvis and another blunt Hohmann retractor in the sciatic notch at the level of the ischiatic spine from the inside of the pelvis, the five osteotomies from inside the pelvic wall may be performed.

The first step is the complete osteotomy of the pubic ramus which is performed through the intermediate window.

The second and third steps are the supra and retro-acetabular osteotomies which are performed through the lateral window.

The fourth step is the incomplete ischiatic osteotomy which can be performed either through the intermediate or the lateral window.

The last step is the "fracture controlled osteotomy" which connects the incomplete ischiatic osteotomy with the retro-acetabular osteotomy and may be done either through the intermediate or the lateral window.

All patients of the series 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 to 10 weeks. Single dose antibiotic prophylaxis with semisyntetic penicillin and antithrombotic prophylaxis with low molecular heparin was given in all patients. The discharge from hospital was usually after 7 to 10 days.

In order to assess the redirection on the acetabular fragment obtainable using the I-I approach, a radiographic evaluation was done with a standard anteroposterior pelvis projection and a false profile view according to Lequesne and de Sèze (22). Deficiency and correction of lateral and anterior coverage were measured by the angles described by Wiberg (lateral center edge angle, CE angle) and Lequesne de Sèze (anterior center edge angle, FP angle) and the obliquity of the sourcil was evaluated by the acetabular index (AC angle).

X-ray assessment was done preoperatively, postoperatively during hospital stay, at 6 to 8 weeks, at 6, 12 months after surgery and then annually.

In order to evaluate the clinical and functional outcome, pain, ambulation and range of motion (ROM) were graded according to the scoring system of Merle d'Aubignè and Postel (23); overall function was assessed before surgery and at last follow-up.

Operating time and blood loss were recorded for each operation. Surgical complications depending on the surgical approach and its additional consequences have been checked and noted.

Figure 4. I-I approach (left side-woman); intraoperative image after the isolation of the vessels and of the iliopsoas muscle and femoral nerve which separate the medial, intermediate and lateral windows.

Results

We re-evaluated all 30 patients of the series with a radiographic assessment and according to the classification system of Merle d'Aubigné. At an average follow-up of 3,11 years (range, 1-7 years) we have recorded the following data.

The preoperative lateral center edge angle (CE angle) according to Wiberg (22) averaged 4,95° (range, -12° - + 30°) and improved to an average of 24,2° postoperatively (range, 7°-47°).

The anterior center edge angle (FP angle) (22) improved from a preoperative average of 16,7° (range 6°-48°) to a mean of 40° postoperatively (range 20°-62°).

The acetabular index angle (22) averaged 24,08° (range, 10°-40°) preoperatively and 11,34° (range 0°-25°) postoperatively.

In the 32 hips the average Merle d'Aubigné (23) score improved from 12,09 points (range 5-17) preoperatively to 15,71 points (range, 7-18) postoperatively.

The functional grading of the hip according to Merle d'Aubigné (23) scoring system was preoperatively poor in 20 patients, fair in 8, medium in 1, good in 2 and very good in 1; postoperatively the same data was poor in 3 patients, fair in 3, medium in 2, good in 12 and very good in 12 (fig. 5).

The evaluation of improvement brought about by operation according to Merle d'Aubigné (23) scoring system was the following:

- very great in 4 patients
- great in 11
- fair in 15
- poor in 2.

Operation time averaged 192 minutes (range, 110-420).

Average blood loss was 2092 ml (range, 750-6900). We observed a damage of the lateral femoral cutaneous nerve with a transitory palsy in 14 cases (44%).

We observed one partial lesion of the ischiatic nerve without paralysis but with persistent severe pain in the leg, treated with a spinal cord stimulator. We had no intraoperative lesion of the large vessels and no thromboembolic complications.

All osteotomies but one healed in the desired position. In the patient with the malpositioned osteotomy a limping gate was present.

In one case we observed a displacement of the initial fixation.

The improved functional grading of the hip was also accompanied by patient satisfaction in 30 out of 32 patients. The unsatisfied patients were the one with severe pain due to the partial lesion of the sciatic nerve and the one with displacement of the initial fixation.

Mean time to consolidation was 3 months.

Discussion

The Bernese PAO was designed to treat symptomatic hip dysplasia. The aim of this surgical procedure is to achieve better coverage of the femoral head with improved load distribution and less pain in order to slow down the progression or to postpone, in asymptomatic patients, the development of secondary os-

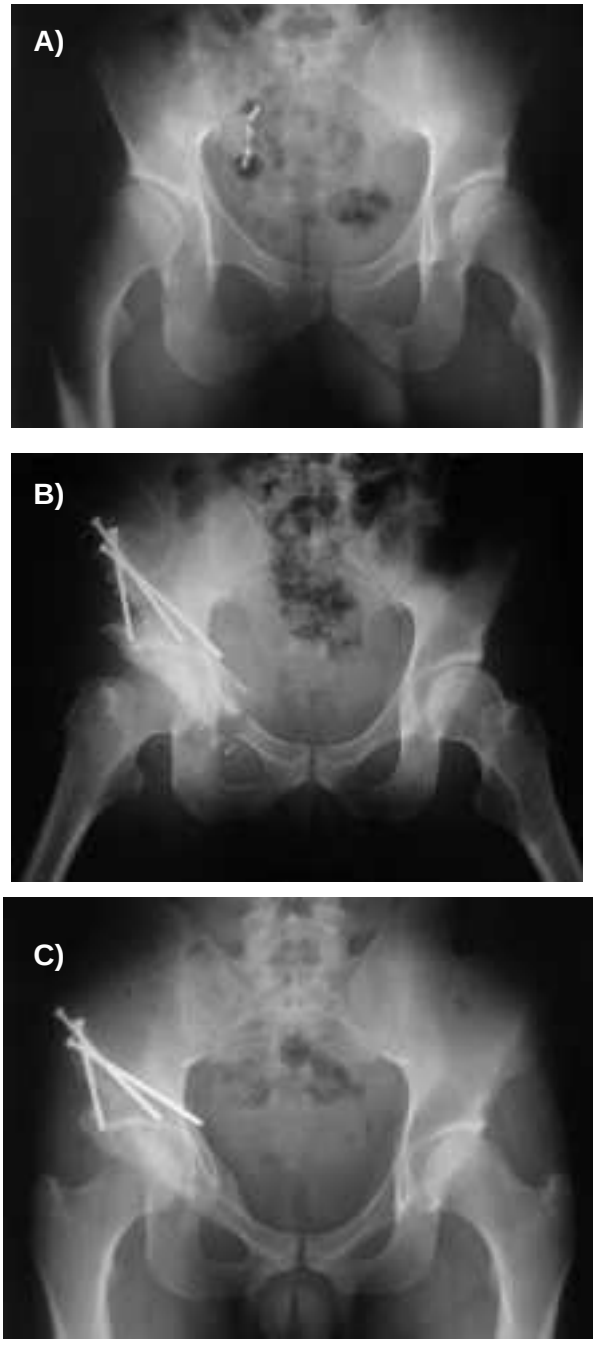

Figure 5. PAO (right hip) through I-I approach and with the use of 3 screws from the iliac crest to the acetabulum. A: pre.op. X-ray. B: post-op. X-ray. C: X-ray after 2 years with consolidation of the osteotomies; very good result.

teoarthritis. The success of this procedure in correction of dysplastic hip is proven (15, 20, 24-26).

The exposure for such surgery is of great importance; the optimal surgical approach is that which combines appropriate exposure with minimal risk and morbidity. Different surgeons use different approaches (15-19) to achieve the same technical result; each exposure represents a balance of advantages and disadvantages.

The classic S-P approach has been associated (17) with a higher rate of functionally limiting heterotopic ossification of the hip, acetabular osteonecrosis, long operation time and considerable blood loss; reattachment of the abductor origins may be unsatisfactory causing prolonged long-term abductor weakness and limping gate.

To avoid these problems Ganz in 1993 (5) introduced the modified S-P approach; through this exposure a less disruptive lateral ilial wing dissection of the abductor muscles decreased the rate of ossification and acetabular osteonecrosis. The operation was less time consuming and had decreased as blood loss presented by Hussel (17).

Other advantages of this approach are that the surgeon achieves the optimal manipulation of the acetabular fragment and exposes the anterior joint capsule with the possibility to perform a capsulotomy to treat intra-articular diseases.

On the contrary, the disadvantages of this approach are the high incidence of lateral femoral cutaneous nerve dysesthesias, the bad cosmesis of the scar and that the first ischiatic incomplete osteotomy is done under indirect vision.

The I-I approach has a lower rate of lateral femoral cutaneous nerve morbidity and leaves entirely intact the external iliac structure with a lower rate of heterotopic ossification. The deep internal pelvic exposure is the best of any approach and the first ischiatic osteotomy is performed under direct vision. The exposure and operating time is longer compared to S-P modified; Hussel (17) has shown that dissection and exposure for S-P modified approach requires approximately 30 minutes, contrasting to the 1 to 1,5 hours for the I-I approach.

Manipulation of the freed acetabular fragment is more difficult and the leverage obtainable can be limited. The fixation of the fragment, because of the absence of external vision, may be more difficult and sometimes an alternative method is needed (internal ilial plate) instead of screw fixation alone. Using the I-I approach no access to the joint capsule is possible and finally vascular complications can be more frequently encountered (lymphatic disruption, secondary seromas, lymphedema, femoral and iliac artery thrombosis) (17).

The direct anterior approach is, although its originator denied any problems with femoral nerve lesions in more than 100 patients (19, 27), considered dangerous for nervous structures. Ganz (17) described 2 of 5 femoral nerve palsies using the direct anterior approach.

The double approach (17) requires long operation time (an additional 1,5 hours operating time) and is seldom used.

All the operations in our presented series have been performed through the I-I approach.

Damage of the lateral femoral cutaneous nerve was present after surgery in 14 cases (44 %) without problems for patients and without the need of any treatment. This data is in contrast to and higher compared to 22% and 35% of lateral femoral cutaneous nerve morbidity described by Letournel (18) and J. Mast (17) using the same approach and compared to 30% of lateral femoral cutaneous nerve morbidity registered by Hussel using the S-P modified approach. We have no explanation for this as every effort was done to protect and preserve the nerve.

Lesion of the sciatic nerve is rare; particular care must be taken not to injure it, by compression or traction, the sciatic nerve, above all during the incomplete osteotomy of the ischium. In this respect the I-I incision is superior to the modified S-P. The lesion when it occurs is usually partial and the recovery is generally spontaneous. In our series we observed one partial lesion of the sciatic nerve with persistent severe pain in the leg, treated with a spinal cord stimulator.

Davey (28) described 3 heterotopic ossifications out of 63 patients treated with S-P modified approach. In our series we didn't observe any external eterotopic ossifications.

Siebenrock (29) in his series, in which he used the S-P modified approach, reported an average operative time of 210 minutes and Matta (24) an average

operative time, including time for removing the drapes, repositioning the patient and for obtaining good quality postoperative x-Ray, of 270 minutes for the patients in which the S-P modified approach was used and of 390 minutes for the patients in whom the I-I approach was used. In our series operation time averaged 192 minutes from skin incision to closure.

Siebenrock (29) in his series reported an average blood loss of 2000 ml and Matta (24) of 800 ml for patients in whom the S-P modified approach was used and 1400 ml for patients in whom the I-I approach was used. In our series the average blood loss was 2092 ml. We noted a definite learning curve in that the operation time and the blood loss decreased with increasing experience of the operation and approach.

The rate of correction of the acetabular deformity, evaluated through CE, FP and AC angle on radiographic images, and the average time to consolidation were satisfactory and similar to results obtained by several surgeons through S-P modified approach (15, 19, 27, 29).

In one case there was a displacement of the initial fixation which required later conversion to a total hip replacement.

The improved functional grading of the hip were also accompanied by the improvement brought about operation and patient satisfaction in 30 out of 32 patients; this in accordance with results of other Authors utilizing S-P modified approach (15, 16, 24, 26, 28, 29).

In spite of serious vascular problems encountered by other Authors (15, 16, 24), we had no intraoperative lesion of the large vessels and no thromboembolic complication using I-I approach.

One drawback with the I-I approach is that it does not allow exploration of the hip joint. Several Authors (15, 19, 27) recommend that this should always be done considering the high incidence of labrum lesions. The significance of such lesions remains to be established. A positive impingement test in combination with confirming MRI findings may be an indication for exploration of the joint in conjunction with PAO through a S-P modified approach.

From our good results and low rate of complications with the I-I approach, we conclude that the incision according to Letournel is safe and gives good exposure for the Bernese periacetabular osteotomy.

References

1. Gallinaro P, Peretti G, Rinaldi E. Displasia congenita delle anche (DCA). Manuale di ortopedia e traumatologia. MacGraw-Hill, Milano, 1998: 41-50.
2. Bombelli R, Santore RF, Poss R. Mechanics of the normal and osteoarthritic hip. *Clin Orthop* 1984; 182: 68-78.
3. Bombelli R. La biomeccanica dell'anca normale e displasica. *Chir Organi Mov* 1997; LXXXII: 117-27.
4. Pawels F. Biomechanics of the normal and diseased hip. Springer-Verlag Berlin Heidelberg New York, 1976.
5. Leunig M, Siebenrock KA, Ganz R. Rationale of periacetabular osteotomy and background work. *J Bone Joint Surg* 2001; 83-A(3): 438-48.
6. Trousdale RT, Ganz R. Post-traumatic acetabular dysplasia. *Clin Orthop* 1994; 305: 124-32.
7. Cooperman DR, Wallensten R, Stulberg SA. Acetabular dysplasia in the adult. *Clin Orthop* 1983; 175: 79-85.
8. Stulberg SD. Unrecognized childhood hip disease: a major cause of idiopathic osteoarthritis of the hip. In the hip. Proceedings of the third open scientific meeting of the hip society. St. Louis, Mosby, 1975: 212-30.
9. Salter RB. Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J Bone Joint Surg* 1961; 43-B: 518-39.
10. Sutherland DH, Greenfield R. Double innominate osteotomy. *J Bone Joint Surg* 1977; 59-A (4): 1082-91.
11. 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.
12. Steel HH. Triple osteotomy of the innominate bone. *J Bone Joint Surg* 1973; 55-A (4): 343-50.
13. Tonnis D, Behrens K, Tscharani F. A modified technique of the triple pelvic osteotomy: early results. *J Pediatric Orthop* 1981; 1: 241-9.
14. Wagner H. Osteotomies for congenital hip dislocation. In The hip. Proceedings of the fourth open scientific meeting of the hip society. CV Mosby, St Louis, 1976: 45-66.
15. Ganz R, Klaue K, Vinh TS, Mast J. A new peri-acetabular osteotomy for the treatment of hip dysplasias. *Clin Orthop* 1988: 232: 26-36.
16. Macnicol MF. Berne periacetabular osteotomy. Color atlas and text of osteotomy of the hip. 1st edition, Mosby-Wolfe, Barcelona, 1996; 7: 51-70.
17. Hussell JG, Mast JW, Mayo KA, Howie DW, Ganz R. A comparison of different surgical approaches for the periacetabular osteotomy. *Clin Orthop* 1999; 363: 64-72.
18. Letournel E. The treatment of acetabular fractures through the ilioinguinal approach. *Clin Orthop*; 1993: 292: 62-76.
19. Millis MB, Murphy SB. The Boston concept. Peri-acetabular osteotomy with simultaneous arthrotomy via direct anterior approach. *Orthopade* 1998; 27: 751-8.
20. Mac Donald SJ, Hersche O, Rodriguez J, Ganz R. The Bernese periacetabular osteotomy for the treatment of adult hip dysplasia. *Chir Organi Mov* 1997; 82 (2): 143-154.

21. Weber M, Ganz R. The bernese periacetabular osteotomy. Surgical techniques in orthopaedics and traumatology. EFORT, Elsevier, 2000: 55-420-C-10.
22. Chevrot A, Wybier M, Gires F, Siala M, Vallèe C, Pallardy G. Imagerie de la hanche; techniques de mesure de la hanche. Encycl Mèd Chir (Paris, France), Radiodiagnostic I, 1988, 30450 F10, 12.
23. D'Aubigne RM, Postel M. Hip arthroplasty with acrylic prosthesis. *J Bone Joint Surg* 1954; 36-A(7): 451-75.
24. Matta MJ, Stover MD, Siebenrock K. Periacetabular osteotomy through the Smith-Petresen approach. *Clin Orthop* 1999; 363: 21-32.
25. Trumble SJ, Mayo KA, Mast JW. The periacetabular osteotomy. *Clin Orthop* 1999; 363: 54-63.
26. Crockarell J, Trousdale RT, Cabanela ME, Berry DJ. Early experience and results with the periacetabular osteotomy. *Clin Orthop* 1999; 363: 45-53.
27. Millis M, Murphy S, Poss R. Osteotomies about the hip for the prevention and treatment of osteoarthrosis. *J Bone Joint Surg* 1995; 77-A(4): 626-47.
28. Davey JP, Santore RF. Complications of periacetabular osteotomy. *Clin Orthop* 1999; 363: 33-7.
29. Siebenrock KA, Scholl E, Lottenbach M, Ganz R. Bernese periacetabular osteotomy. *Clin Orthop* 1999; 363: 9-20.

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