Lessons learned after more than 250 periacetabular osteotomies

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ABSTRACT The Bernese periacetabular osteotomy (PAO) has become the procedure of choice in many centers for the treatment of young patients with symptomatic hip dysplasia in the absence of severe secondary arthrosis. This article concerns our institution's "learning curve" with this procedure and focuses on patient selection, exposure, technical aspects of performing the bone cuts, mobilizing the fragment, and obtaining proper correction.

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Developmental hip dysplasia is a structural hip disorder that can lead to degenerative joint disease. When nonoperative methods have failed, total joint arthroplasty remains the procedure chosen for the elderly patient and those with endstage cartilage loss. Younger patients having hip dysplasia, but without marked degenerative joint disease should continue to rely on surgical intervention without arthroplasty (i.e., joint-preserving surgery) to help control pain and hopefully retard the progression of degenerative changes. Of all the various osteotomies that have been developed to improve the joint mechanics in young patients with symptomatic hip dysplasia, the Bernese periacetabular osteotomy (PAO) has shown promising midterm results and has become the preferred procedure in our institution for the treatment of developmental hip dysplasia in the absence of severe secondary degenerative changes. This procedure has come to the forefront thanks to its balance between minimal exposure, complications, and ability to provide optimal correction (Ganz et al. 1988). It has many advantages: 1) it permits correction coverage medially, laterally, and anteriorly as needed while at the same time maintaining proper acetabular version; 2) it can be performed through a single incision, without damaging the abductors; 3) the pelvic ring and outlet are not disrupted, which permits early mobilization, there is no need for cast or brace immobilization, and it allows for future vaginal delivery without complication; and 4) one can perform a capsulotomy to assess the labrum and check for impingement without compromising the acetabular blood supply (Ganz et al. 1988, Trousdale et al. 1995).

Although this operation has many advantages, its "learning curve" is long. From 1992 to the present, more than 250 periacetabular osteotomies have been done in our institution. The purpose of this paper is to highlight what we have learned after performing many osteotomies in the hope of shortening the "learning curve" for others who are beginning to do this operation.

Who is a good candidate for a periacetabular osteotomy?

As with any operative procedure certain patients are more likely to have a more satisfactory outcome. The ideal patient for a reconstructive pelvic osteotomy is relatively young (probably less than 50–55 years old), has little, if any, arthrosis (Tönnis grade II or less), has a poorly covered femoral head with a lateralized hip center of rotation, not obese, and perhaps most importantly, has a round head, and a round acetabulum suitable to obtain a congruent hip (Figure 1) (Trousdale et al. 1995). An abduction-internal rotation view of the hip is often helpful and should show a congruent hip with an adequate joint space. Patients with such radiographic findings and activity-related groin pain do extremely well with a well-performed reorientation osteotomy. As we have become more adept with this procedure, we have expanded its indications to young patients with mild to moderate arthrosis (Tönnis grade II or less) or out-of-round femoral heads and/or acetabulae, but in this patient subgroup it should be considered a salvage operation with a much less predictable outcome (Figure 2).

Figure 1. An excellent candidate for osteotomy. Note absence of arthritis with a round femoral head and acetabulum.

Figure 2. A poor candidate for osteotomy. Joint space is narrow and femoral head is markedly out-of-round.

Preparation and exposure

We place the patient on an image table. Most patients have the procedure done under regional epidural anesthesia. Epidural anesthesia and maintaining the systolic blood pressure below 110 mmHg helps to minimize blood loss. Preoperative autologous blood donation and intraoperative cell saver are of value for reducing the need for allogeneic blood. A Foley catheter and an epidural catheter are introduced and left in place for 24–48 hours postoperatively.

Intraoperative EMG monitoring (of the tibial, peroneal divisions of the sciatic nerve and femoral nerves) is useful and has reduced our incidence of permanent neurologic injury to less than 1% (McGrory and Trousdale 1994, Pring et al. 2002). Such surgery can be performed through a variety of approaches: ilioinguinal, two incisions, direct anterior, or various modifications of the Smith-Peterson approach (Crockarell et al. 1999, Hussell et al. 1999, Matta et al. 1999, Mayo et al. 1999). In 1992, we first performed this procedure, using an anterior incision with exposure of both the inner and outer tables of the pelvis (McGrory et al. 1993). This required removal of the abductor origin from the outer aspect of the ilium, which improved visualization, but it resulted in slower healing of the bone and slower recovery of abduction and of improvement in the postoperative limp. In the last approximately 150 patients, we have used the same skin incision and performed the osteotomy through the inner aspect of the pelvis leaving the abductors completely intact on the outer aspect of the ilium. This has dramatically improved the rate of healing, time-to-weight bearing, and improvement in the limp. It is not uncommon to see a patient at 8 weeks after surgery free from crutches and with little, if any, limp when using this abductor-sparing approach.

The incision begins along the border of the iliac crest 6–8 cm proximal to the anterior superior iliac spine. It continues from the anterior superior iliac spine down over the anterior inferior iliac spine,

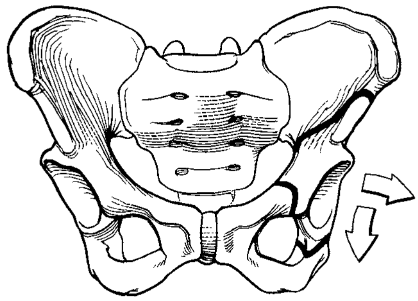


Figure 3. Locations of osteotomies.

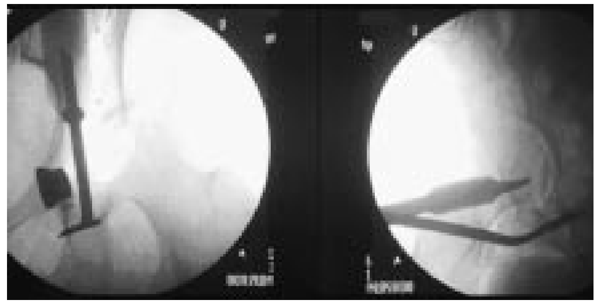


Figure 5. Intraoperative anterior-posterior image (left) and at 65° (right) showing the correct location of an ischial osteotomy. Note that the Homan retractor has been placed in the pubic bone to facilitate exposure.

curving distally and ending at about 3 cm distal and anterior to the greater trochanter. The internerve plane between the tensor fascia lata and sartorius is extended. Incision of the deep fascia over the tensor fascia lata muscle belly will help to avoid injury to the lateral femoral cutaneous nerve. The sartorius is released from the anterior superior iliac spine. The hip is flexed and adducted (which relaxes the anterior neurovascular structures and iliopsoas muscle) and the inner table is exposed down to the sciatic notch. The anterior iliacus capsular insertion is sharply removed and followed distally until the iliopsoas sheath is entered. The pubic bone is exposed and a Homan retractor placed to retract the iliopsoas tendon medially. The direct head of the rectus femoris is released from the anterior inferior iliac spine. Using scissors, dissection is continued distally and medially to palpate the ischium and obturator foramen. Alternatively, a direct anterior approach can be used without removing any muscle, but we have no experience with that approach.

Performing the osteotomies

Performance of the osteotomies has become straightforward (Figure 3). Image intensification has proved to be invaluable and has taken most of the stress out of performing the osteotomies (Figure 4). The image intensifier is utilized at 4 locations when we make the osteotomies.

1. When performing an ischial osteotomy, an image is obtained to ensure that the osteotomy is sufficiently distal and medial and oriented in the proper direction (Figure 5). The osteotomy is performed with a 30° bifid osteotome. The posterolateral aspect of the ischium should be left intact. The osteotome is inserted and can be left in place as a guide when performing a posterior iliac osteotomy. One can usually feel this osteotome medially and distally over the quadrilateral surface.

2. When performing the pubic cut, one should make sure that it is medial enough to prevent its entry into the joint. The incision is made in an oblique direction (proximal medial to distal and lateral), which facilitates mobilization of the frag-

Figure 4. Photograph from operating room showing how the anteroposterior (left) and oblique (right) images are taken.

Figure 6. Intraoperative anterior-posterior image showing location of the iliac osteotomy. Note the considerable distance between the joint and the osteotomy.

Figure 8. An attempt at correction with hinging occurring inferiorly. Note that the acetabular teardrop has not shifted, which indicates hinging. No medialization has occurred.

ment. The obturator nerve should be protected with suitable retractors.

3. When performing the iliac incision, which is generally done at or just below the anterior superior iliac spine, an image is obtained to ensure that one is high enough above the joint to permit adequate fixation of the distal fragment (Figure 6). It is also useful to direct the iliac incision somewhat distally, so that when making the turn to connect the iliac incision with the ischial incision, the osteotomy is distal to the top of the sciatic notch.

4. Lastly, and most importantly, when performing a posterior iliac osteotomy, an intraoperative oblique image can be obtained to ensure that the incision is extra-articular and does not damage the posterior column of the acetabulum. The image intensifier can be used when the iliac osteotomy is connected to the ischial osteotomy (Figure 7).

Mobilizing the fragment

The orthogonal incisions are useful since they are reproducible and relatively easy to make. However, they have some minor disadvantages. They induce minor, and probably clinically insignificant, translation movements in the osteotomized fragment after correction is induced. More importantly, the orthogonal incisions can "catch" or impinge, especially inferiorly and posteriorly when one tries to obtain correction. One should be careful not to hinge the fragment into correction, an error which is easily detected on radiographs (Figure 8). If the fragment is hinging, the acetabular teardrop will not rotate. Hinging usually occurs at the posterior-inferior corner where the ischial incision meets the posterior iliac incision. This corner can be trimmed with an osteotome or rongeur, but care should be taken not to injure the sciatic nerve. When all 3

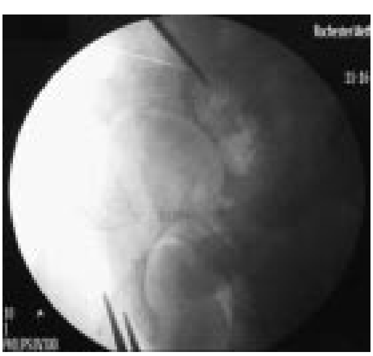
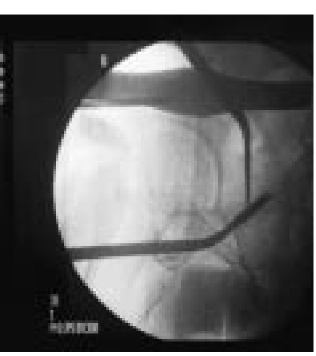


Figure 7. A. Intraoperative oblique image showing a posterior iliac osteotomy. Note that the osteotomy is extra-articular and the posterior column is left untouched.



B. Two oblique images showing when the iliac osteotomy is connected with the ischial osteotomy.

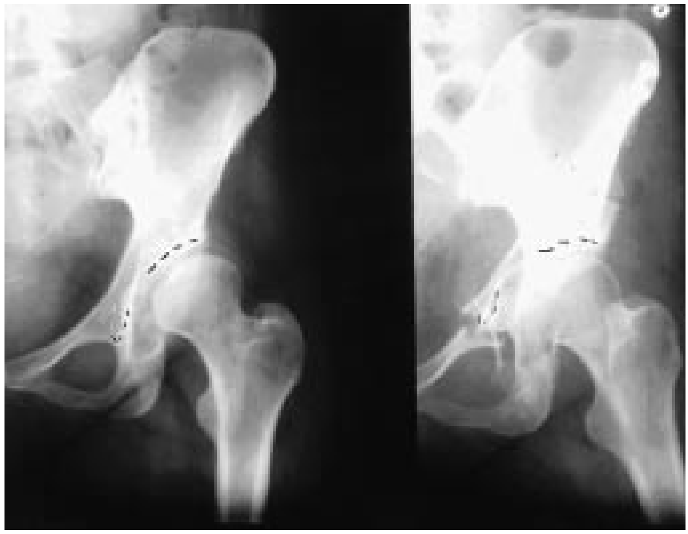
osteotomies are completed, the posterior column is left intact and the acetabular fragment should be completely free and mobile.

Correction

Obtaining proper correction is the most difficult and critical part of the operation. We feel it is helpful to think of proper correction in 4 steps: 1) correct lateral coverage (adduction); 2) correct medialization of the hip center of rotation; 3) correct anterior-posterior coverage; and 4) correct acetabular version (extension). A mistake in correction in any one of these planes can lead to suboptimal coverage with a reduction in the contact area of the hip joint, an increase in joint forces secondary to poor coverage and/or lateralization of the hip center, and anterior impingement with or without posterior subluxation of the hip in cases of excessive anterior correction.

When assessing correction intraoperatively, it is imperative to take a true anterior-posterior pelvic radiograph (symmetrical obturator foramen with the coccyx ending 3–4 cm proximal to the symphysis) in the operating room before final fixation. If the pelvis is tilted in any direction, it will be impossible to assess anteversion, medialization accurately, etc.

Figure 9. Before and after correction.

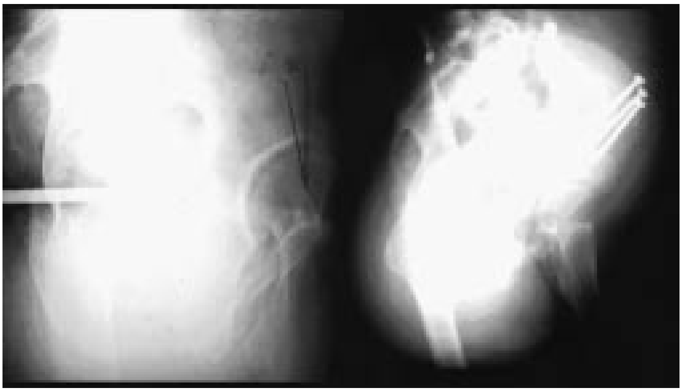


A. Note the Tönnis angle has been normalized.

B. Note correct medialization.

1. Lateral correction. Lateral correction (adduction) is best assessed by normalizing the weight bearing surface or sourcil of the acetabulum (Tönnis angle) (Tönnis 1987). The lateral margin of the weight bearing surface should be just superior to the medial margin (Figure 9). It is important not to overcorrect laterally as this can lead to impingement laterally and may bring the fovea into the weight bearing surface. If the Tönnis angle has been normalized and the Wiberg angle is still less than optimal, consideration should be paid to performing a varus femoral osteotomy. Intraoperative fluoroscopy in abduction and adduction is useful when the acetabulum has been corrected to confirm whether a femoral osteotomy will be helpful. Occasionally, excessive anteversion on the femoral neck can be detected with a CT scan or preoperative physical examination and may need to be corrected.

2. Medialization. Most dysplastic hips have a hip center that is excessively lateralized. Medialization allows one to reduce the joint contact forces by reducing the body weight lever arm. If



C. Note proper anterior correction.

D. Note adequate maintenance of acetabular anteversion. Anterior rim marked by solid line, posterior rim by dotted line.

the contralateral hip is normal, one can use it as a guide to proper medialization. However, bilateral involvement is not uncommon. In this case, the ilioischial line which is not affected by this osteotomy, can be used as a guide for proper medial correction. In many caes, placement of the medial aspect of the femoral head just lateral (0–5 mm) to the ilioischial line provides satisfactory medialization (Figure 9).

3. Anterior correction. It is very easy to overcorrect anteriorly. This can cause anterior impingement of the femoral neck on the anterior rim of the acetabulum with a secondary limitation of hip flexion. In extreme cases, excessive anterior correction may lead to posterior subluxation of the femoral head. Anterior correction is sufficient when the anterior rim of the acetabulum covers about one-third of the femoral head and less than the posterior rim (Figure 8).

4. Anteversion. It is very easy to retrovert (flex) the acetabular fragment when inducing anterior correction. Retroversion (flexion) of the acetabulum will also cause anterior femoral-acetabular impingement with hip flexion and internal rotation (Myers et al. 1999). This should be prevented and can be assessed intraoperatively. The medial wall of the pelvis and medial wall of the fragment should remain relatively parallel if correct anteversion is maintained. If not, parallel retroversion (flexion) of the socket has probably occurred. On a true anteroposterior radiograph of the pelvis with a temporary fixation in place, the relationship between the anterior rim and posterior rim relative to the lateral edge of the weight bearing sourcil will give an indication of anteversion. If the anterior wall covers less of the femoral head than the posterior wall and they meet at the lateral aspect of the sourcil on a true anterior-posterior pelvic radiograph, the socket is adequately anteverted. If the posterior wall meets the sourcil medial to the anterior wall at the lateral sourcil rim, the socket is retroverted (overextended) (Figure 8).

Postoperative care

We routinely use an epidural catheter (with infusion of a narcotic which allows for postoperative neurological assessment) for postoperative pain relief during the first 24–48 hours after surgery. Although deep venous thromboses have been rare (about 1%), we continue to use aspirin for 6 weeks. We begin weight bearing at 6 weeks with abduction exercises, water exercises, and a stationary bike at 4 weeks.

Complications

Many complications may occur during and after this procedure. The incidence of these complications declines as one passes the learning curve. Davey and Santore (1999) emphasized this when they reported a decline in their major complications from 3 in their first 35 cases to 1 in the second 35 cases of periacetabular osteotomy. The duration of surgery in our series has been reduced significantly. When we began to perform this operation, it took 5–6 hours, on average. The average time is now slightly less than 2 hours. Heterotopic ossification, symptomatic hardware, infection, and wound problems are relatively rare. We have had 3 known deep venous thromboses in the first 250 patients 1 of whom had an asymptomatic pulmonary embolus. Major neurological problems are also relatively uncommon. Pring et al. (2002) recently reported our use of intraoperative EMG monitoring during periacetabular osteotomy and found that about one-fourth of the patients are at risk during the procedure, but only 0.7% had a peroneal nerve palsy more than 1 year from the procedure. None of our patients has had femoral or tibial nerve injuries. Postoperative numbness along the distribution of the lateral femoral cutaneous nerve is very common with the anterior incision that we use. The numbness has resolved in most of these patients after 1 year. 1 patient had neurolysis of the lateral femoral cutaneous nerve for persistent dysesthetic pain, but it did not relieve his symptom. No major vascular injuries have occurred. The average blood loss in our patients currently is about 350 ccs. We continue to use an intraoperative cell saver, but no longer have patients donate autologous blood. Symptomatic osteotomy nonunion is also rarely a problem. The iliac osteotomy has healed in all of our patients. We have had 2 ischial nonunions, one of which required bone grafting. About 9% of our patients have pubic nonunion on radiographs. This is directly related to the severity of the dysplasia. Patients requiring major correction have larger displacements of the pubic bone and therefore the likelihood of nonunion is greater. We have not reoperated on any of these patients. The main problem we have had with this operation is failure to obtain optimal correction. In reality, there is only one optimal correction for every patient with hip dysplasia. We have already discussed how to obtain proper correction.

Conclusion

Although we have had a long learning curve for this procedure, these tips will hopefully shorten the curve for others. It is helpful to visit a center that regularly performs this procedure. “Practice” on several cadavers when learning this procedure is essential. Having a second surgeon who is interested in hip dysplasia and pelvic reconstructive osteotomies is invaluable, especially when performing the initial cases and when deciding whether a proper correction has been obtained. A well-performed osteotomy in a properly selected patient is an extremely rewarding procedure for the patient with symptomatic hip dysplasia (Murphy et al. 1990, 1999, Trousdale et al. 1995, Siebenrock et al. 1999, Trumble et al. 1999).

No competing interests declared.

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