

THE MINIMAL INVASIVE PERIACETABULAR OSTEOTOMY (PAO) FOR ADULT HIP DYSPLASIA SURGICAL TIPS AND TRICKS

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SUMMARY

Background: Periacetabular osteotomy (PAO) is an established surgical intervention for symptomatic developmental dysplasia of the hip (DDH) in skeletally mature patients, aimed at optimizing femoral head coverage and delaying secondary osteoarthritis. Traditional techniques involve extensive soft tissue dissection, necessitating modifications to reduce surgical morbidity and accelerate postoperative recovery.

Objective: This article describes a modified minimally invasive PAO technique utilizing a bikini incision and muscle-preserving approaches, detailing the surgical steps, preoperative planning, and clinical indications.

Key Points: Preoperative assessment requires digital 2D planning to target a lateral center-edge angle of 30° and a femoral extrusion index $\leq 25\%$. The modified technique employs a short ilioinguinal (bikini) incision and preserves the origins of the sartorius and rectus femoris muscles. Four distinct osteotomies—ischial, pubic, supraacetabular, and retroacetabular—are performed through two surgical windows. Maintaining a 1-cm posterior column bridge is critical for pelvic stability and early mobilization. Intraoperative assessment of the hip range of motion is mandatory; if impingement persists despite optimal acetabular reorientation, a concomitant femoral head-neck osteochondroplasty is performed via a Smith-Petersen interval. Postoperative protocols include 50% weight-bearing for four weeks and pharmacological prophylaxis against heterotopic ossification.

Conclusion: The modified minimally invasive PAO provides effective radiographic correction of DDH while minimizing soft tissue trauma. Success depends on precise preoperative planning, maintenance of posterior column integrity, and intraoperative verification of impingement-free range of motion to ensure favorable clinical outcomes in young adults with mild to no preoperative osteoarthritis.

KEYWORDS

Acetabulum; Bone Nails; Hip Dislocation, Congenital; Osteotomy; Surgery, Minimally Invasive

INTRODUCTION

In 1988, Ganz et al. first described the surgical procedure of periacetabular osteotomy (PAO) for acetabular reorientation. PAO is an extensive surgical procedure performed in young adults with symptomatic DDH to improve function of the hip joint and delay the development of secondary osteoarthritis. The goals of acetabular reorientation are to optimize femoral head coverage, normalize joint mechanics and reduce the risk of secondary osteoarthritis.

Prior to the development of the PAO, the triple osteotomy was the primary procedure for acetabular reorientation to treat symptomatic DDH in skeletally mature patients¹. The technical advantages of PAO compared to the triple osteotomy include increased postoperative stability through preservation of the continuity of the posterior acetabular column, allowing for faster mobilisation, protection of the acetabular perfusion and preservation of the internal pelvic diameter, allowing for normal child birth^{2 3 4}.

While the original surgical technique of the PAO required an extensive skin incision and detachment of both the Sartorius and Rectus femoris muscle origins, newer minimally invasive surgical techniques allow for singular and shorter skin incisions (bikini incision), preservation of muscular attachments and minimization of soft tissue trauma, aiding in a faster postoperative patient recovery. The original Ganz PAO represents an effective surgical procedure with low complications rates and excellent long-term outcomes^{5 6}. In this paper we will describe our experience and surgical tips and tricks with a modified minimal invasive PAO.

CLINICAL EXAMINATION

Prior to surgery, a thorough history and physical examination are obligatory. The physical examination should include a careful assessment of gait pattern, leg lengths, joint stability, and range of motion.

PREOPERATIVE IMAGING AND PLANNING

Highquality radiographs must be obtained to enable an accurate assessment of the degree of acetabular dysplasia and allow for precise determination of the optimal amount of acetabular correction. An anteroposterior pelvic overview in proper rotation and tilt, a Dunn lateral view (e.g., 45-degree projection) and a false profile (faux profile) view of the affected hip should be performed. To estimate the amount of postoperative correction, the congruency between acetabulum and the femoral head ability and containment of the femoral head and additional radiograph in functional abduction and internal rotation should be obtained.

The radiological criteria for a DDH are currently defined as a lateral CE-angle of less than 23°. Other radiological markers are an acetabular index greater than 14° and a femur extrusion index greater than 27°⁴. Prior to surgery the authors recommend a digital planning to determine the optimum amount of acetabular reorientation and avoid over- or under-correction (Fig. 1) in anteroposterior pelvic overview. This is done using the identical digital 2D planning software for arthroplasty procedures (TraumaCad, BrainLab, Munich). On the anteroposterior pelvic

overview, a postoperative LCE angle of 30° , a positive acetabular index, a femoral extrusion index $\leq 25\%$ and an anteverted acetabulum are the target values for correction.

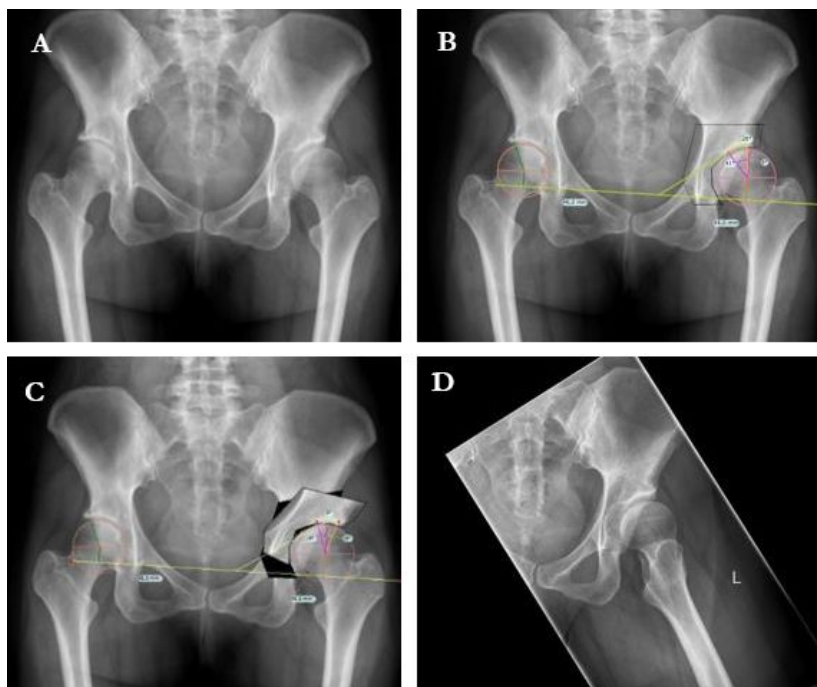


Fig. 1 PlanningA: standard pelvic ap viewB before planning and reorientationC after planning before reorientationD standard axial viewDigital preoperative planning is done on anteroposterior pelvic overview. Planning of the key lines are shown preop. After correction a better acetabular reorientation can be found with optimization of femoral head coverage and better joint mechanics.Furthermore, a standard axial view radiograph is done of the femoral head to evaluate the head-neck offset.

In addition to the evaluation of the radiographic osteoarthritis grade, MRI is recommended to assess the status of the acetabular and femoral cartilage as well as the acetabular labrum and femoral offset.

INDICATION AND CONTRADICTION FOR PAO

The most common indication for a PAO is a symptomatic radiological DDH in young adults. Prerequisite for performance of this procedure is a closure of the triradiate cartilage of the acetabulum. The most significant factor predicting the outcome and long-term survival after PAO is the degree of preoperative osteoarthritis. Patients with none to mild preoperative osteoarthritis (Toennis grade 0 or 1) are good candidates for PAO.

Although, patients over 30 years of age show a reduced outcome, compared to younger patients, after PAO, advanced age only represents a relative contraindication. In the author's experience patients older than 40 years can also be candidates for PAO. However, these cases must be evaluated on an individual basis depending on the preoperative presence or grade of osteoarthritis and labral degeneration, as depicted by MRI. Patients with a poor preoperative range of motion in the affected hip joint are also poor candidates for a PAO.

Absolute contraindications for PAO are advanced stage osteoarthritis (Toennis grade 2 or 3), subluxation of the femoral head with a neoacetabulum or an incongruity between the femoral head and acetabulum.

SURGICAL TECHNIQUE FOR PAO

The patient is positioned supine on a radiolucent table to allow for intraoperative radiographs (Fig. 2). The first modification of the MIS PAO technique, versus conventional PAO is the bikini skin incision. The bikini skin incision (ilioinguinal) starts 2cm lateral from the anterior third of iliac crest to the anterior superior iliac spine (ASIS) and then follows the skin fold over the inguinal ligament toward the symphysis (Fig. 3).

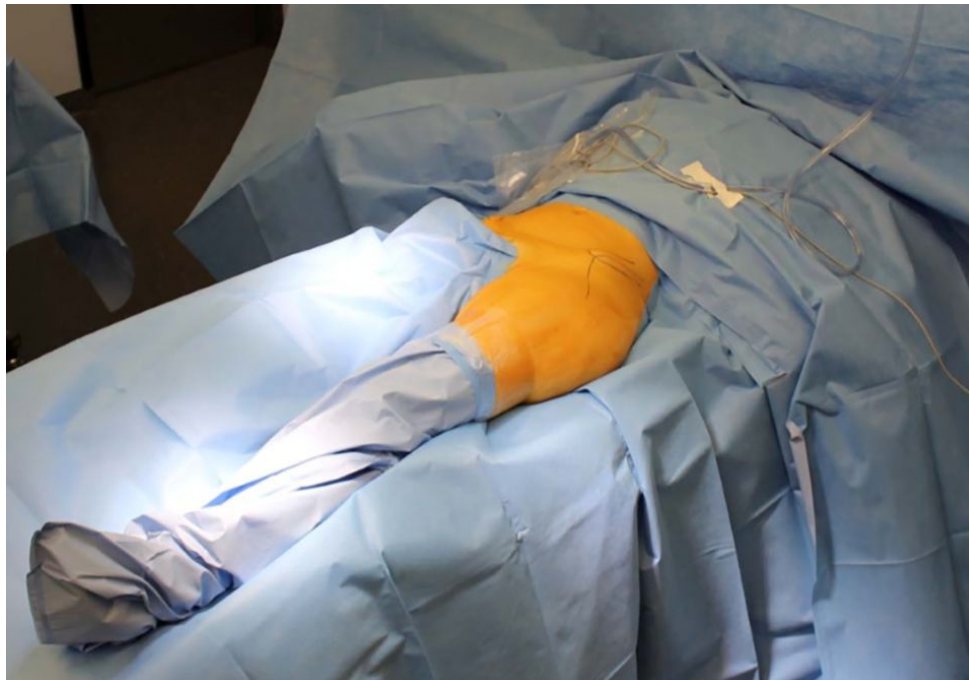


Fig. 2 Supine position on radiolucent table

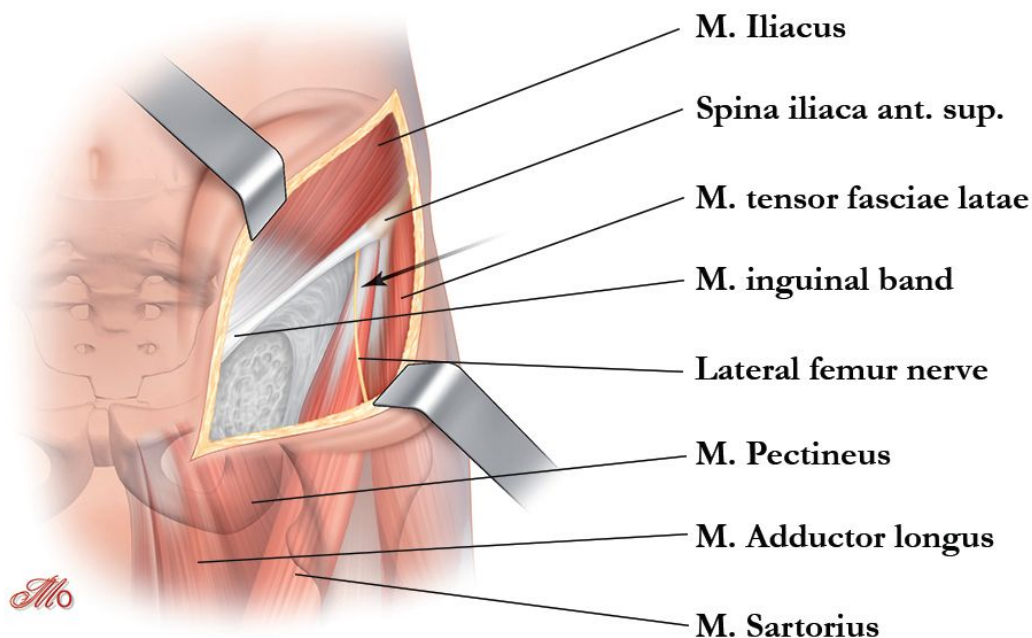


Fig. 3 Bikini scin incision

After the skin incision has been made, the subcutaneous fatty tissue is retracted. The fascia of the M. tensor fasciae latae (TFL) is incised and split longitudinally in the direction of the muscle fibers. The muscle belly of the TFL is peeled off its fascial sheath and mobilized laterally to protect the lateral femoral cutaneous nerve, which

enters the surgical field under the inguinal ligament and passes from the belly of the Sartorius laterally towards the TFL (Fig. 4). The lateral cutaneous nerve lies in proximity to the following incisions and is at risk for direct or indirectly damage over retractor pressure during the course of the PAO. To secure the lateral femoral cutaneous nerve, we mobilise and display the nerve to medial at this point of the operation.

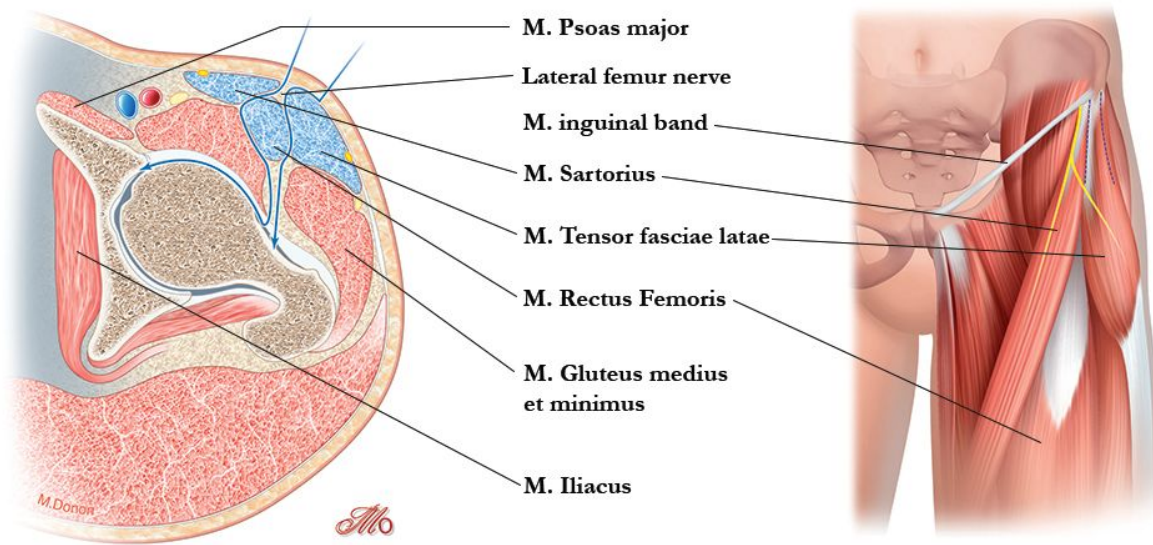


Fig. 4 Surgical approaches Fig 4 A: Transversal view and Fig 4 B anterior view of the approach through M tensor, sartorius and rectus femoris

The second and third modifications of MIS-PAO are the retainment of the origin of the sartorius and rectus femoris muscles. These modifications are performed to minimize the soft tissue trauma and allow a faster recovery.

During the further course of the surgery two windows are used for the visualization of the four osteotomies

1. proximal ilioinguinal window for the supra- and retroacetabular osteotomies
2. distal window for the ischium and pubis osteotomies

The first surgical ilioinguinal window for the supra- and retroacetabular osteotomy is performed to expose the inner part of the pelvis, posterior acetabular column and medial acetabular wall (Fig. 5). The window is created through dissection of the abdominal, iliacus muscles and inguinal ligament from the iliac crest and extended through blunt dissection along the medial surface of the iliac wing until the iliac fossa.

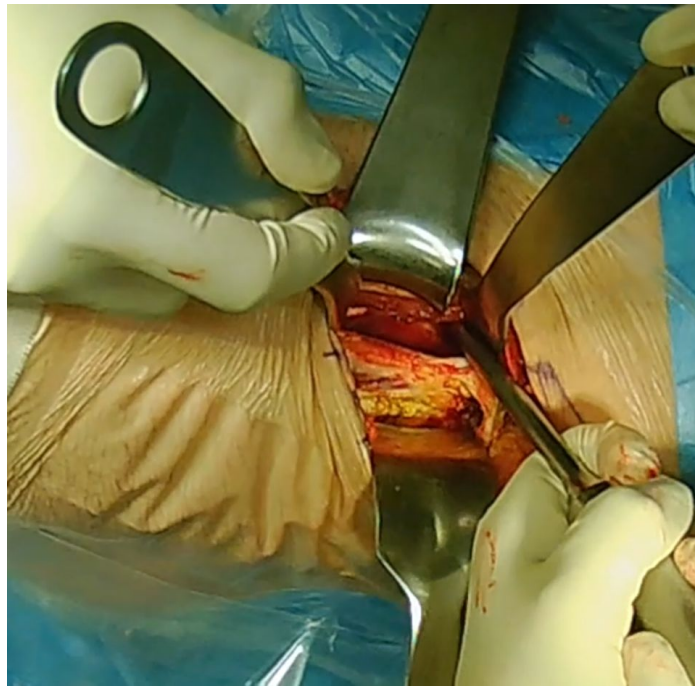


Fig. 5 Ilioinguinal window Shows exposer of the inner part of the pelvis with blunt dissection of the iliacus muscle for the supra- and retroacetabular osteotomies

The second surgical window is for the approach to the osteotomies of ischium and pubis (Fig. 6). For access of the ischium the Sartorius and the lat cunctaneous nerve is retracted medially and the TFL is retracted laterally. After dissection of this interval the iliopsoas and rectus muscles are encountered. The fascia of the rectus muscle is now incised longitudinally, as this reduces soft tissue tension and facilitates the ischium osteotomy. To access the ischium the surgeon now retracts the rectus laterally with Langenbeck retractor and the iliopsoas medially via Hohmann retractor, to protect the neurovascular bundle.

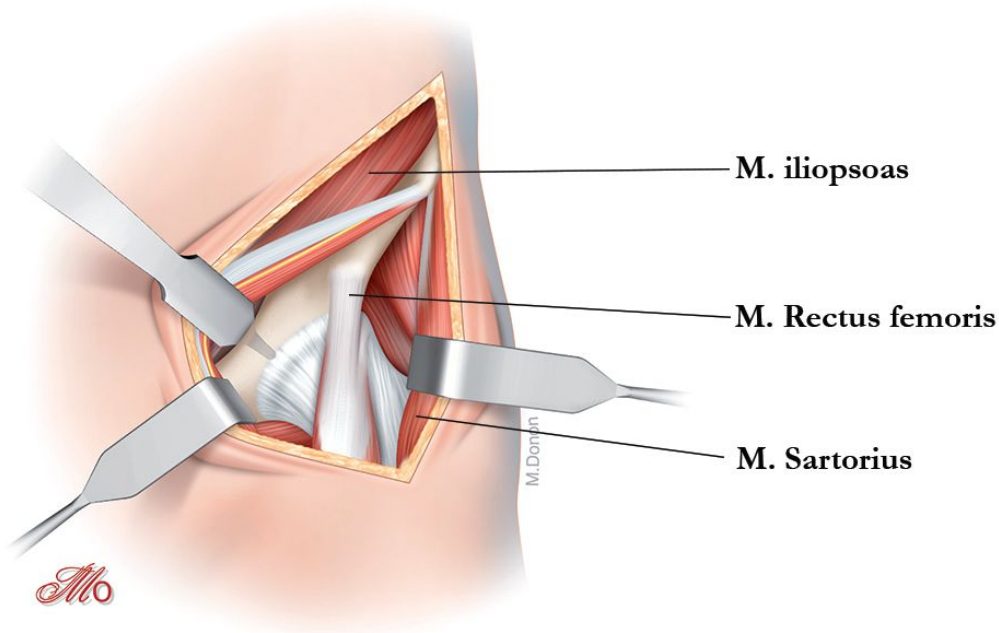


Fig. 6 Distal window: Shows exposure for the ischium and pubis osteotomies

The next step is to strictly move on the hip joint capsule, which was displayed before, between the iliopsoas and rectus muscles with a Cobb-raspatory towards the os ischium. This interval is used to insert a curved osteotome for the osteotomy of the os ischium.

The incomplete ischium osteotomy, preserving the posterior half of the posterior acetabular column, is performed under radiological control with a curved 15mm osteotome. The osteotomy is initiated at the infracotyloid groove, which can be palpated very clearly with the tip of the osteotome, and ascends toward the spina ischadica (Fig. 7). At this point of the operation the surgeon needs to be aware of the anatomical proximity of the sciatic nerve, avoid Intraarticular penetration with the osteotome and guard against transection of the posterior column (Fig. 7, 8). To reduce the risk of nerve injury, the hip is flexed and abducted for the osteotomy of the medial ischium (Fig. 9). For the osteotomy of the lateral ischium the leg is extended and externally rotated.

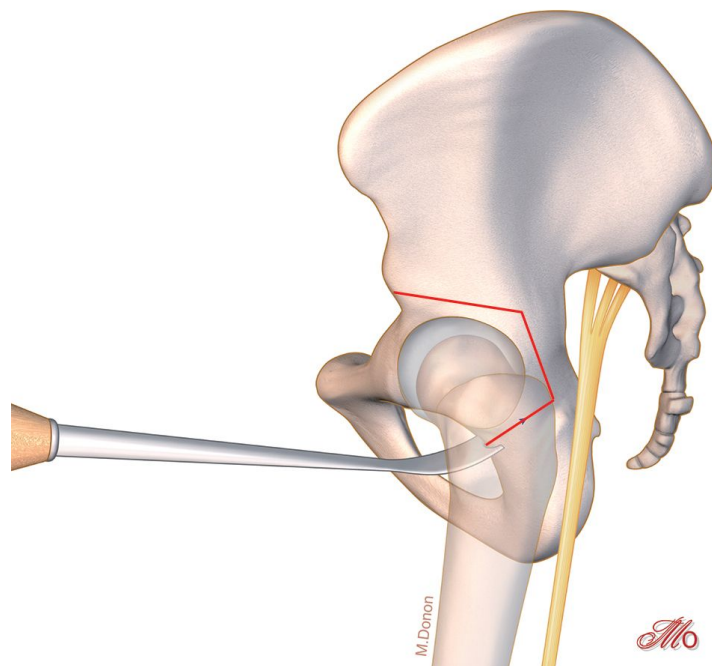


Fig. 7 Scheme of ischium osteotomy

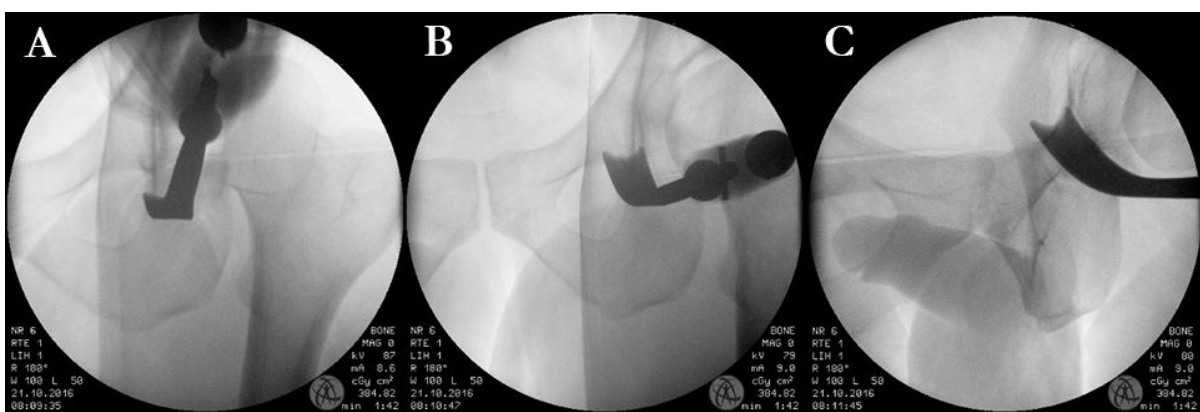


Fig. 8 Intraoperative ischium osteotomy under x-ray A: AP view starting point B: AP view medial osteotomy C: Axial view to control intact post column



Fig. 9 Flexed leg during ischium osteotomy

After the incomplete ischium osteotomy, the exposure of the pubis is performed using two blunt retractors placed around the pubis. Next the periosteum is carefully peeled from the bone and Hohmann retractors are placed under the periost around the pubic ramus to protect the neurovascular obturator bundle during the complete osteotomy of the pubis. The pubic osteotomy is performed medial of the pubic eminence in a sagittal angel of 30° under radiographic control using an oscillating saw first and a 15 mm chisel second (Fig. 10).

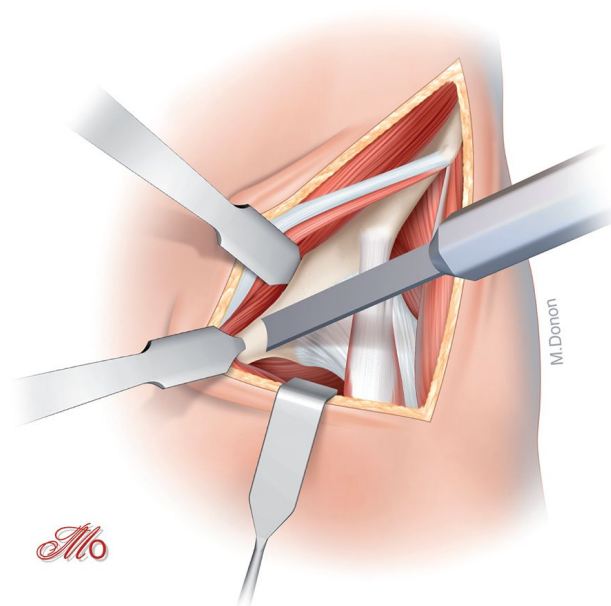


Fig. 10 Pubis osteotomy The neurovascular bundle is protected with two Hohmann retractors

The first ilioinguinal window is now used for the supra- and retroacetabular osteotomies.

The next osteotomy is the supraacetabular osteotomy. Prior to the osteotomy the abductors are bluntly dissected from the iliac wing and protected with a Hohmann retractor (Fig. 11). The osteotomy is initiated under the ASIS

and the origin of the Sartorius. The osteotomy is then continued horizontally over the acetabulum until about 1 cm from the Linea ilipectinea (Fig. 12, 13).

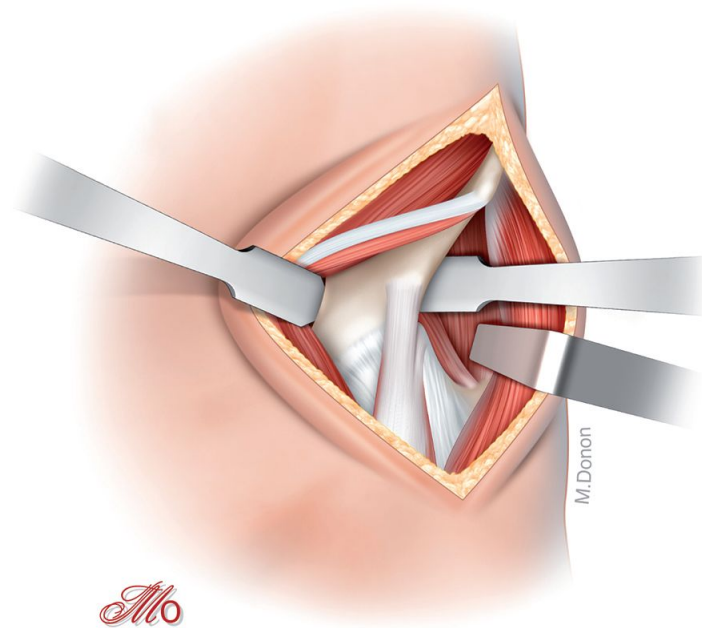


Fig. 11 Blunt dissection of Abductors from iliac wing This allows to perform supraacetabular osteotomy

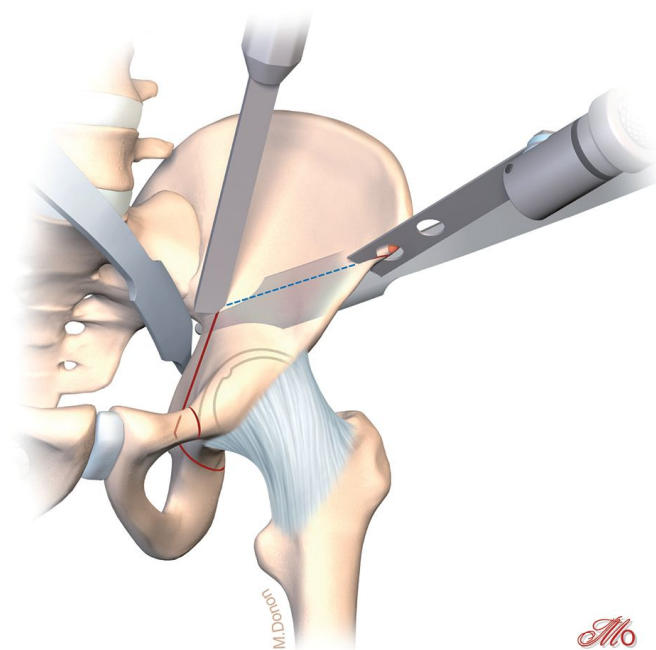


Fig. 12 Supraacetabular osteotomy view from front

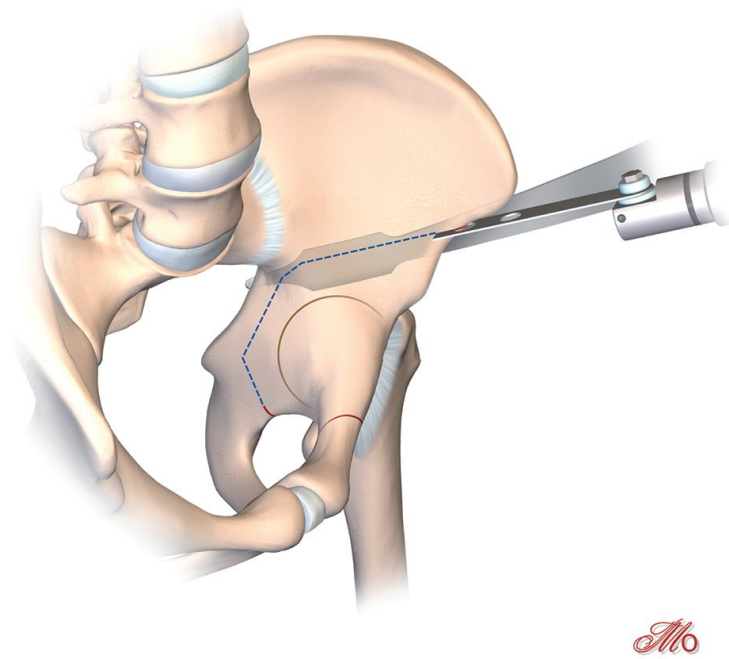


Fig. 13 Supraacetabular osteotomyview from inside

The retroacetabular osteotomy is performed at an angle of 110° relative to the supraacetabular osteotomy under fluoroscopic control (Fig. 14). Care must be taken to maintain a minimum bone stock of 1 cm prior to the sciatic notch to ensure the integrity of the posterior half of the posterior acetabular column. This ensures the continuity of the posterior column and provides the pelvic stability needed for postoperative mobilization and weight bearing.



Fig. 14 Retroacetabular osteotomy under x-ray

After these osteotomies the acetabular fragment should be careful mobilized with a laminar spreader and 1 Steinmann-pin (Fig. 15). Often there are still some bone brides between the ischium and the retroacetabular osteotomies. These bridges should be broken with a curved osteotome which is placed under fluoroscopic control and after spreading the osteotomy with a laminar spreader. After all osteotomies are finished, acetabular

reorientation remains a difficult step and care should be taken to achieve proper acetabular reorientation. The goal of reorientation is an LCE of 30°, a positive acetabular index and an anteverted acetabulum. The reoriented acetabulum is then temporarily secured by two Kirschner wires that bridge the supraacetabular osteotomy (Fig. 15).

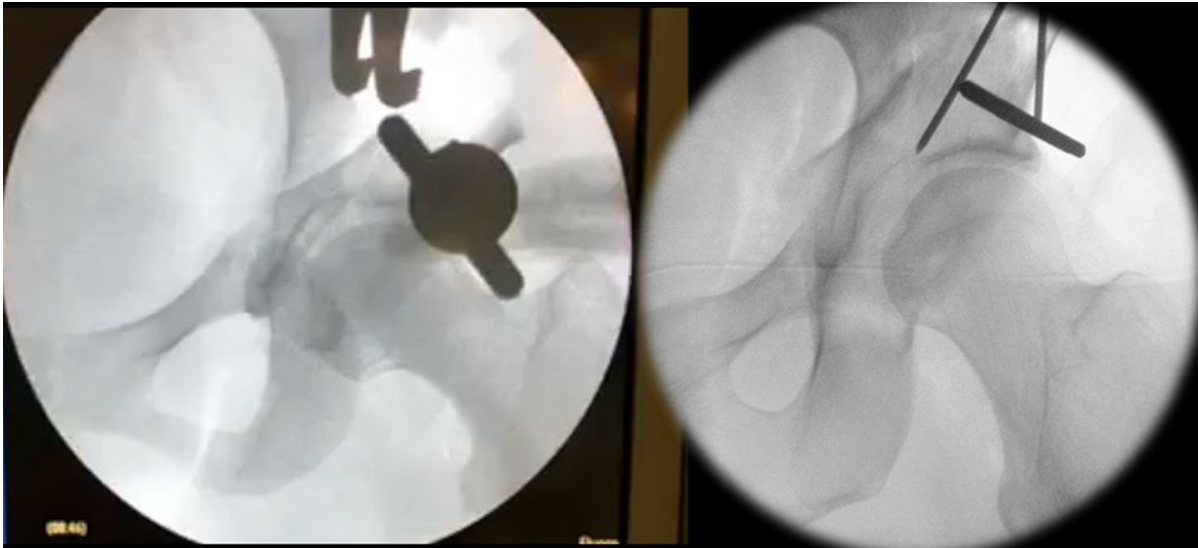


Fig. 15 Mobilization of acetabular fragment and temporary fixation with the help of a laminar spreader and two Steinman pins the fragment can be mobilized. After reorientation temporary fixation with Kirschner wires under fluoroscopic control

To avoid postoperative limitation in ROM or femoroacetabular impingement the freedom of motion after reorientation and before definite fixation of the acetabular fragment should be checked with minimum of 120° flexion and 30° internal rotation in 90° hip flexion. If an optimal acetabular reorientation and adequate ROM has been achieved the acetabular fragment is definitely fixed with four 4,5mm screws. The screw placement is verified with fluoroscopy to verify their extraarticular position (Fig. 16).

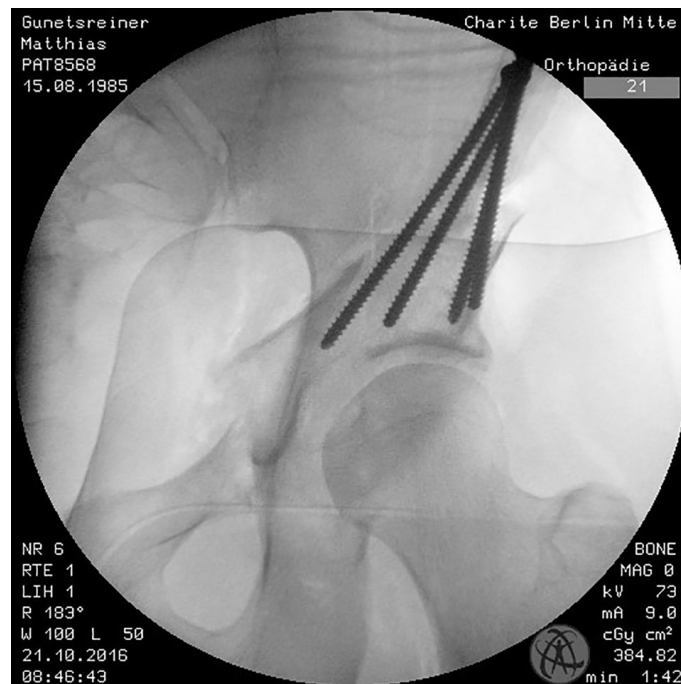


Fig. 16 AP view of final correction fixed by four 4.5 mm screws with extraarticular position

If this targeted ROM is not achieved, and the acetabular reorientation is correct an additional head-neck offset correction has to be performed. This offset correction is done via a classical direct anterior approach (Smith-Peterson interval) utilizing the interval medial of the tensor and lateral of the rectus and the sartorius muscle. The interval between the M. sartorius and the M. tensor fascia latae (TFL) is bluntly dissected and two blunt curved Hohmann retractors are inserted to expose the capsule of the hip joint. The proximal insertion of the M. rectus femoris is bluntly liberated with a gauze-covered Cobb-raspatorium. Placement of a broad Hohmann retractor on the anterior acetabular column under the proximal insertion of the M. rectus femoris. T-shaped capsulotomy. The medial aspect of the capsulotomy should occur under visualization to avoid accidental damage to the labrum. Intracapsular placement of both blunt Hohmann retractors above and below the femoral neck (Fig 17).



Fig 17: Capsulotomy for reshaping of the femoral head-neck offset

Now remodulation of the femoral asphericity with a high-speed burr can be performed. The remodulation should extend right up to the acetabular labrum, without touching or damaging the labrum. Mobilization of the leg to visualize the hip joint and control the impingement-free range of motion. The minimum acceptable range of motion is 120° of flexion and 30° of internal rotation under simultaneous 90° of flexion. Radiographic control: A complete removal of the femoral asphericity is achieved (Fig 18).



Fig 18: Axial view of the new achieved femoral head-neck

When closing the wound, Lavage and careful haemostasis has to be performed. The surgeon must reattache the pelvic musculature to the iliac crest with non-resorbable sutures.

TECHNIQUE TIPS AND TRICKS

The most important step for a successful osteotomy is achievement of an adequate exposure through a sufficiently long skin incision. When referring to a minimally invasive procedure the authors are referring to minimizing muscle damage and not minimizing the length of the skin incision. An adequate exposure is most important for the retroacetabular osteotomy. An under-sized skin incision can affect the trajectory of the retroacetabular osteotomy, due to soft-tissue conflict, and results in intraarticular fractures or fracture of the posterior acetabular column.

The pubic osteotomy should be started with a small oscillating saw and completed with a straight osteotome to avoid an uncontrolled splitting of the pubic bone. The pubic osteotomy should also be angled downward and medially. A too vertical orientation of the pubic osteotomy can result in a lateralization of the acetabular fragment due to a conflict at the site of the pubic osteotomy, resulting in the inability of the os pubis to move medially.

The supra-acetabular osteotomy should be performed a minimum of 3cm cranial of the acetabular dome to allow for sufficient space for insertion of both Steinmann pins. The reorientation of the acetabular fragment can be difficult if there is not enough supra acetabular bone to insert a single Steinmann pin only.

In cases of a very caudal position of the ASIS it is sometimes necessary to start with an additional osteotomy right below the ASIS and extend this osteotomy 1.5 cm cranially behind the origin of the ASIS prior to initiating the supra acetabular osteotomy. This guarantees enough supraacetabular bone stock to insert two Steinmann pins.

The retro-acetabular osteotomy should be centered in the posterior acetabular column and not be performed too close to the acetabulum. The bone stock directly behind the acetabulum is very thick and difficult to osteotomize. If the retro-acetabular osteotomy is not performed completely and too much force is applied via the laminar spreader during the reorientation of the acetabular fragment there is a risk of inducing an intraacetabular

fracture through the acetabular fossa. The bone stock around the acetabular fossa is very thin and this area is at an increased risk of fracture if excessive force is applied during the reorientation procedure.

In case of difficulties to mobilize the acetabular fragment, the authors recommend the insertion of a lambot osteotome into the retroacetabular osteotomy to equally distribute the force across the entire posterior column of the acetabulum during reorientation. This maneuver gives the surgeon very good feed-back regarding the mobility of the fragment and if needed the incomplete osteotomies can be checked and performed again.

PERIOPERATIVE REHAB PROGRAM

Arcoxia 90 mg is provided for 21 days postoperatively as a prophylaxis against heterotopic ossification. Antithrombotic medication Fragmin P forte 1x1 sc. is given until normal mobilization is achieved. Postoperative mobilization is performed under 50% weight-bearing with crutches for 4 weeks and progressed to full weight bearing until the 6th post-operative week. To check the stability of postoperative fixation and bone healing, an ap pelvic x ray should be obtained before full weight bearing (Fig. 19, 20). Low-impact sports can be initiated after the 6th postoperative week. No limitations regarding the ROM are given, but physical therapy is gently started after 2-4 weeks.



Fig. 19 Preoperative pelvic overview

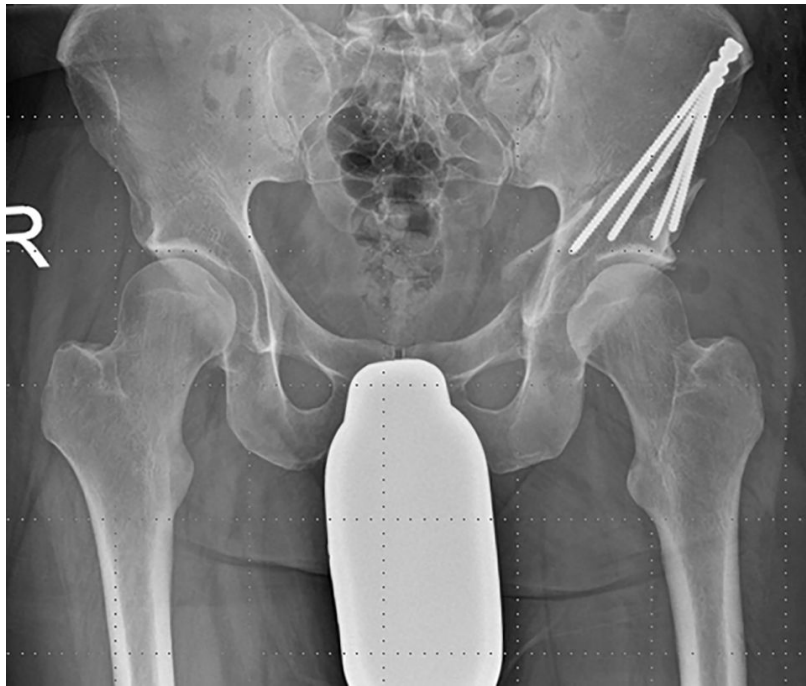


Fig. 20 Pelvic overview 4th postoperative week shows good correction of the dysplastic deformity and beginning consolidation of the osteotomy

DISCUSSION/CONCLUSION

The PAO is a joint-preserving technique that successfully modifies the natural course of acetabular dysplasia in adolescent patients, providing better radiographic outcomes and a low amount of complications. In comparison to other pelvic osteotomies a greater correction can be realised, and there is less distortion of the pelvic symmetry. With careful planning and execution, the modified less invasive PAO presented in this paper can be used to obtain reasonable and good anatomic correction of hip dysplasia.

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