

Anteverting Periacetabular Osteotomy for Acetabular Retroversion

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Introduction

The periacetabular osteotomy procedure reorients a retroverted acetabulum into a more anatomically appropriate position.

A periacetabular osteotomy is indicated for patients with substantial acetabular retroversion who present with a combination of radiographic findings (Fig. 1): a positive crossover sign (with a retroversion index exceeding 30%), a positive posterior wall sign, and a positive ischial spine sign. Typically, this procedure is performed in patients up to thirty-five years of age who have symptomatic femoroacetabular impingement (Video 1).

The patient is placed in a supine position, and the skin is incised in the inguinal fold extending along the anterior third of the iliac crest. Detachment of the abdominal wall muscles, the sartorius muscle, and the inguinal ligament expose the iliac fossa and pelvic brim. The infra-articular space is accessed by detachment of the iliocapsularis muscle¹ from its origin along the hip joint capsule and by lateral retraction of the tensor fasciae latae muscle. A partial ischial osteotomy is performed followed by an osteotomy of the superior pubic ramus. The supra-acetabular osteotomy starts at the level of the anterior superior iliac spine and is angled distally to intersect with the incomplete ischial osteotomy. The posterior column is preserved, maintaining an intact continuity of the pelvic ring. Acetabular version typically is corrected by internal rotation of the acetabular fragment. The reoriented acetabular fragment is temporarily fixed with Kirschner wires, and orientation is checked with an intraoperative pelvic radiograph. Definitive fixation is performed with three 3.5-mm cortical screws. In the majority of cases, a concomitant arthrotomy with femoral head offset correction (deepening of the concave contour of the femoral neck) is performed to enable sufficient internal rotation of the femur within the acetabulum.

Step 1: Evaluation of Acetabular Retroversion

Evaluate acetabular retroversion on the basis of a combination of radiographic signs (Fig. 1).

- The three key radiographic signs used to describe acetabular retroversion are the crossover sign^{2,3}, the posterior wall sign^{2,3}, and the ischial spine sign^{3,4} (Fig. 1). In addition, the retroversion index allows quantification of the amount of acetabular retroversion⁵ (Fig. 1).
- Substantial acetabular retroversion is identified by a positive crossover sign^{2,3} with an acetabular retroversion index exceeding 30% in combination with a positive posterior wall sign^{2,3} and a positive ischial spine sign^{3,4}.
- An acetabular retroversion index of 30% indicates that the cranial 30% of the anterior wall overlaps the posterior wall. That means that the crossover sign can be found at a point comprising 30% of the entire acetabular opening.
- We think that, in general, substantial acetabular retroversion in young symptomatic patients up to the age of thirty-five years is best treated with an anteverting periacetabular osteotomy.

Step 2: Patient Positioning and Skin Incision

After draping and sterile preparation with the patient in a supine position, make an incision following the skin lines of the inguinal fold (Figs. 2 and 3).

- Place the patient in a supine position in the middle of a radiolucent table.
- Carry out sterile preparation and draping of the entire hemipelvis up to the inferior ribs and the affected lower limb. It is important to have sufficient access to the anterior and middle thirds of the iliac crest. Drape the affected lower limb freely within the surgical field to allow mobility.

- Make a skin incision in the inguinal fold one finger width below the anterior superior iliac spine (Fig. 2). The incision length is about 12 cm with the middle of the incision located inferior to the anterior superior iliac spine.
- Mobilize a combined skin and subcutaneous soft-tissue flap distally, exposing the fascia of the thigh over the tensor fasciae latae and sartorius muscles (Fig. 3).
- Perform a longitudinal incision of the fascia of the tensor fasciae latae muscle over a length of about 10 cm. Take care not to make the incision over the sartorius muscle in order to protect the lateral femoral cutaneous nerve, which typically exits the pelvis underneath the inguinal ligament medial to the anterior superior iliac spine. The superior portion of the nerve follows the sartorius muscle before branching laterally and distally in relation to the thigh (Fig. 3).

Step 3: Exposure of the Deep Muscle Layers and the Pelvic Brim

Detach the abdominal wall muscles from the anterior iliac crest and detach the sartorius muscle and the inguinal ligament to expose the iliac fossa and the pelvic brim (Fig. 4 and Video 1, Time Point 0:38).

- Bluntly mobilize the tensor fasciae latae muscle laterally from the fascia, separating this muscle from the sartorius muscle. Then incise the deep fascia layer longitudinally, exposing the iliocapsularis and the rectus femoris muscles.
- Place the leg onto a leg holder with the hip flexed about 40° and the knee bent.
- Detach the abdominal wall muscles from the anterior third of the iliac crest. Bluntly separate the iliacus muscle from the iliac fossa and mobilize the muscle medially toward the pelvic brim.
- Sharply detach the origins of the sartorius muscle and the inguinal ligament from the anterior superior iliac spine and retract them medially together with the abdominal wall muscles. Medial retraction of the muscles is facilitated by placing a curved blunt retractor over the pelvic brim.

Step 4: Surgical Dissection for Preparation of the Ischial Osteotomy

Detach the iliocapsularis muscle and mobilize it medially to allow access to the infra-articular space and palpation of the ischial bone (Fig. 5 and Video 1, Time Point 2:26).

- Place a pointed Hohmann retractor into the superior pubic ramus medial to the iliopubic eminence, which marks the point of union of the

ilium and pubis. This Hohmann retractor allows medial retraction of the iliopsoas muscle.

- Define the interval between the rectus tendon and the iliocapsularis muscle. Sharply dissect and detach the iliocapsularis muscle from the underlying capsule and the anterior inferior iliac spine from lateral to medial. Retract the rectus femoris muscle laterally and the iliocapsularis muscle medially.
- The anteroinferior portion of the capsule is exposed. Open the infra-articular space by inserting and spreading a pair of curved scissors. Typically, the iliopsoas tendon becomes visible on the medial side. With the help of the scissors, the proximal aspect of the ischium and the posterior horn of the acetabulum can be palpated.

Step 5: Incomplete, Partial Ischial Osteotomy

Introduce a curved chisel with a crescent-shaped tip into the infra-articular space in order to perform the osteotomy of the ischial bone (Fig. 6 and Video 1, Time Point 4:17).

- Insert a broad, blunt periosteal elevator into the infra-articular space (Video 1, Time Point 4:29). This instrument serves to guide a special curved chisel with a crescent-shaped tip onto the anterior aspect of the ischial bone. If required, use an image intensifier to ensure the correct position of the chisel.
- Perform the osteotomy of the ischial bone to a depth of 4 to 5 cm (Video 1, Time Point 5:33). The sciatic nerve lies in proximity to the osteotomy of the ischium. During this phase, the assistant should constantly hold his or her hand on the patient's foot to sense any mechanical irritation to the nerve (Video 1, Time Point 4:55).
- Estimate the advancement of the chisel in the bone by the distance between the skin and the handle of the chisel. Less experienced surgeons should use fluoroscopic imaging (an outlet and an iliac oblique view) to monitor the advancement of the tip of the chisel in the bone.
- It is important to understand that the ischial osteotomy is an incomplete cut of the ischial bone that should not exit into the lesser sciatic notch. The incomplete osteotomy of the posterior column ensures stability of the pelvic ring. If the posterior column is accidentally cut, the stability of the pelvic ring is reduced, requiring touch-down weight-bearing for eight weeks.

Step 6: Osteotomy of the Superior Pubic Ramus

Place subperiosteal blunt retractors around the superior pubic ramus to ensure safe and complete pubic bone osteotomy (Fig. 7 and Video 1, Time Point 5:45).

- Place a pointed Hohmann retractor into the superior pubic ramus about 3 cm medial to the acetabular eminence, which represents the anterior wall of the acetabulum.
- Use a blunt narrow periosteal elevator to elevate the periosteal layer of the superior pubic ramus cranially from the bone along the pelvic brim and caudally from the pubic bone. Insert two blunt curved retractors around the superior pubic ramus with the retractor tips entering the obturator foramen. This maneuver ensures that (1) the osteotomy of the pubic bone is medial to the hip joint, and (2) the corona mortis vessels, which typically represent an anastomosis between the obturator and the external iliac vessels, are protected.
- Notch the superior pubic ramus with two converging cortical cuts using a thin sharp chisel. Then complete the osteotomy with a broad chisel.
- Through medial retraction, the femoral nerve, the femoral artery, and femoral vein are safely protected.

Step 7: Supra-Acetabular and Retroacetabular Osteotomy

Start the supra-acetabular horizontal osteotomy at the anterior superior iliac spine and end it 2 cm lateral to the pelvic brim, where the osteotomy is angled 100° distally (Fig. 8 and Video 1, Time Point 7:27).

- At the level of the anterior superior iliac spine, detach the abductor muscles from the bone over a width of 5 cm. Tunnel the abductor muscles in the dorsal direction with a blunt instrument. Insert a blunt curved retractor to protect the muscles during the supra-acetabular osteotomy.
- Using an oscillating saw, start the horizontal osteotomy immediately inferior to the anterior superior iliac spine and end it about 2 cm lateral to the pelvic brim (Fig. 8).
- Two centimeters lateral to the pelvic brim, angle the retroacetabular osteotomy about 100° distally, aiming at the ischial spine (Fig. 8). Perform the osteotomy with a straight chisel. For better visualization of the quadrilateral plate, insert a curved blunt retractor with its tip on the ischial spine.

- Break the lateral cortex of the iliac bone next to the pelvic brim with a curved 15-mm-wide chisel. Ideally, the retroacetabular cut should meet and intersect the first incomplete ischial osteotomy.

Step 8: Mobilization of the Acetabular Fragment

With the help of a spreader and a 4.5-mm threaded Schanz pin, free and mobilize the acetabular fragment (Fig. 9 and Video 1, Time Point 9:41).

- Insert a 4.5-mm threaded Schanz pin at the level of the anterior inferior iliac spine in a slightly cranial direction.
- Place a laminar bone spreader into the proximal portion of the retroacetabular osteotomy site.
- With the help of the threaded Schanz pin and the spreader, internally rotate the acetabular bone fragment to break the lateral cortex of the iliac bone. If the fragment cannot be mobilized adequately (typically due to a remaining bone bridge between the retroacetabular and ischial cuts), insert the curved special chisel on the quadrilateral plate to connect the retroacetabular osteotomy with the ischial osteotomy (Video 1, Time Point 9:15). The acetabular fragment has to be freely mobile in order to proceed with the acetabular reorientation.

Step 9: Reorientation of the Acetabular Fragment

Perform internal rotation of the acetabular fragment with the help of the threaded Schanz pin (Fig. 10 and Video 1, Time Point 9:56).

- Internal rotation of the acetabular fragment with the help of the threaded Schanz pin is the most efficient way to correct acetabular retroversion. Typically, the internal rotation does not exceed 10° to 20°.
- Occasionally, a cranial wedge of about 10° has to be resected from the acetabular fragment to allow additional flexion of the fragment, which may be required to avoid excessive lateral coverage (a lateral center-edge angle of >30° or a negative acetabular index⁶).
- Perform preliminary fixation with threaded 2.5-mm Kirschner wires.
- Test internal rotation with the hip in 90° of flexion.
- Obtain an intraoperative anteroposterior pelvic radiograph with the patient on a “sandwich table,” on which the patient does not need to be moved during insertion of the x-ray plate. Often, multiple reorientation attempts with repeated

intraoperative anteroposterior pelvic radiographs are necessary to achieve an optimal correction.

- Perform definitive fixation of the acetabular fragment with three 3.5-mm cortical screws.

Step 10: Improvement of Anterior Head-Neck Offset (Femoral Neck Osteoplasty)

Anterior capsulotomy and improvement of anterior head-neck offset is recommended when internal rotation is $<30^\circ$ (Fig. 11).

- Ideally, a minimum of 30° of internal rotation in 90° of flexion should be present in order to largely avoid persistent anterior femoroacetabular impingement. Thus, when internal rotation is $<30^\circ$, deepen the concavity of the femoral neck after an anterior T-shaped arthrotomy is performed.
- Place two blunt retractors around the femoral neck.
- Define the location of the cam deformity with dynamic assessment of the hip after the capsulotomy. Typically, a cam deformity is located in the anterosuperior area of the head-neck junction.
- With a curved chisel and a high-speed burr, deepen the concavity of the contour of the femoral neck, thereby improving the anterosuperior offset. Internal rotation in 90° of flexion can be tested under visual control until 30° of internal rotation is achieved.
- Close the wound in layers with absorbable sutures.
- Perform transosseous refixation of the origin of the sartorius muscle with a nonabsorbable suture.

Step 11: Anteroposterior Pelvic Radiograph Following Periacetabular Osteotomy

Ideally, a postoperative radiograph should show negative crossover and posterior wall signs while the ischial spine sign typically remains positive (Fig. 12).

- Following acetabular reorientation, the crossover and posterior wall signs disappear with correct acetabular anteversion. Since the posterior column with the ischial spine is preserved with the periacetabular osteotomy, the ischial spine sign typically remains positive following acetabular reorientation.

Results

The long-term results of the periacetabular osteotomy in a series of twenty-two patients (twenty-nine hips) with

symptomatic acetabular retroversion were evaluated after a mean duration of follow-up of eleven years (range, nine to twelve years)⁷. The mean age at the time of the operation was twenty-three years (range, fourteen to forty-one years). A concomitant arthrotomy with offset correction was performed in twenty-four hips (83%) to achieve sufficient internal rotation of 30° . In the vast majority of the patients, the clinical results (Merle d'Aubigné score and prevalence of a positive anterior impingement test) and the radiographic morphology of the acetabulum improved or were normalized. None of the hips was converted to a total hip arthroplasty. Four patients (four hips; 14%) required revision surgery, including three patients (three hips) who underwent surgical hip dislocation because of overcorrection of acetabular reorientation and/or untreated cam-type femoroacetabular impingement and one patient (one hip) who underwent revision periacetabular osteotomy because of partial loss of correction. Factors that predicted a good long-term outcome following periacetabular osteotomy for the treatment of acetabular retroversion were head-neck offset correction in hips with insufficient internal rotation and a correct acetabular reorientation that avoided undercorrection and overcorrection.

We are not aware of any other follow-up studies on periacetabular osteotomy as treatment for symptomatic acetabular retroversion. It is difficult to compare the results from the literature on surgical rim trimming in hips with acetabular retroversion because of the heterogeneity of the patient populations and the differences in the severity of acetabular retroversion. Generally, the results of acetabular rim trimming for treatment of acetabular retroversion seem to be inferior to those of periacetabular osteotomy⁷.

What to Watch For

Indications

- Substantial acetabular retroversion with a positive crossover sign, positive posterior wall sign, and positive ischial spine sign.
- We believe that the acetabular retroversion should account for a minimum of about 30% of the entire acetabular opening.
- Typically, these patients are young—no more than thirty-five years of age.
- Clinically, these patients present with symptomatic anterior femoroacetabular impingement with groin pain and decreased hip flexion and internal rotation. The anterior impingement test (internal rotation in 90° of flexion) results in reproducible hip pain.

Contraindications

- Acetabular reorientation should not be performed in patients with advanced osteoarthritis

of the hip (exceeding grade 1 according to the system described by Tönnis⁸).

- Minor acetabular retroversion (a retroversion index of <30%) can be treated with surgical hip dislocation and trimming of the excessive, anterior part of the acetabular rim. However, care must be taken to trim the rim only a moderate amount in order to not decrease the joint contact area to a critical level instead of reorienting the acetabulum. Rim trimming is an option only in hips with minor acetabular retroversion and a nondysplastic posterior wall.

Pitfalls & Challenges

- Increasing posterior coverage through anteverting acetabular reorientation may lead to posterior intra-articular impingement. This may require subsequent posterior rim trimming.
- Anteverting periacetabular osteotomy increases the risk of posterior femoroacetabular impingement in hips with additional high femoral anteversion⁹. Additional femoral derotation osteotomy must be considered.
- Anteverting periacetabular osteotomy tends to

create a high lateral coverage (an excessive lateral center-edge angle and a low acetabular index^{3,10}). This may be encountered with additional flexion of the acetabular fragment. Flexion is best performed after resecting an anterior-based wedge of the acetabular fragment.

Clinical Comments

- Because the continuity of the pelvic ring is preserved following periacetabular osteotomy, patients can be mobilized on the first postoperative day with the help of two crutches and partial weight-bearing of 15 to 20 kg for eight weeks.
- Since acetabular retroversion is due to malorientation of the acetabulum rather than the acetabular rim being excessive anteriorly and deficient posteriorly¹¹, acetabular reorientation is a more logical treatment. Rim trimming potentially can result in insufficient acetabular coverage.
- To achieve sufficient internal rotation of the hip of at least 30°, a concomitant arthrotomy with a head-neck offset correction is indicated in the majority of cases.

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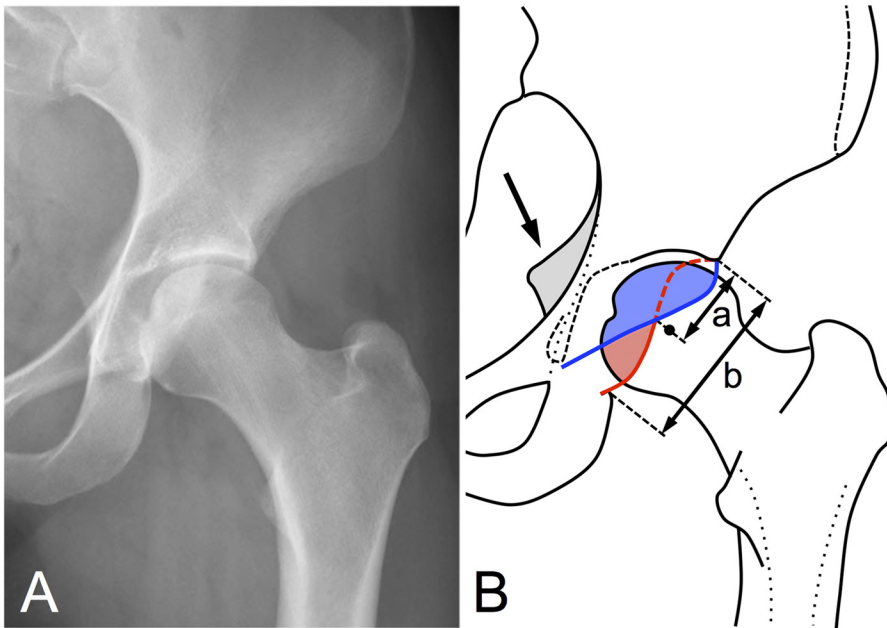


Fig. 1
 Acetabular retroversion is best evaluated on an anteroposterior pelvic radiograph with use of three radiographic signs: the crossover sign, the posterior wall sign, and the ischial spine sign. The crossover sign is considered positive if the anterior rim (blue line) crosses the course of the posterior rim (red line). The amount of retroversion can be quantified with the retroversion index, which is calculated as the ratio of the retroverted acetabulum (a) to the entire opening of the acetabulum (b). In a normal hip, the acetabulum is anteverted with a negative retroversion sign and a corresponding retroversion index of 0%. A hip with substantial acetabular retroversion typically presents with a retroversion index exceeding 30%. The posterior wall sign is positive if the posterior wall (red line) runs medial to the femoral head center (black dot). The ischial spine sign is considered positive if the ischial spine (single-headed arrow) is projected medial to the pelvic brim.

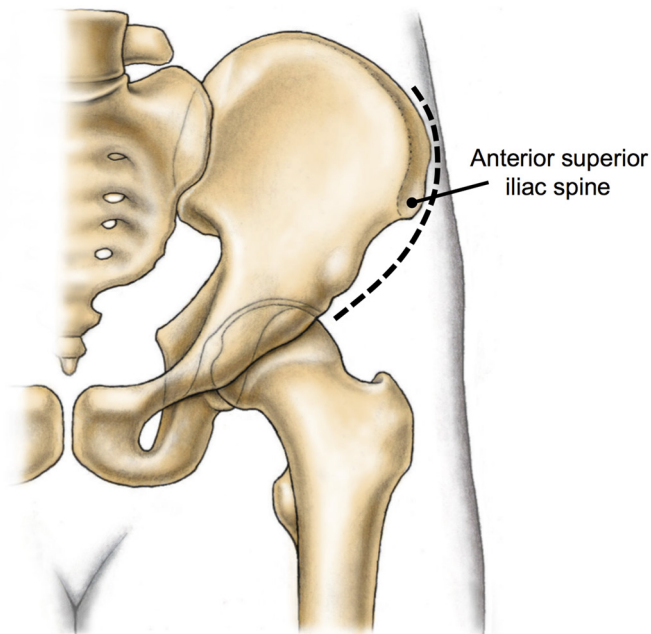


Fig. 2
 The skin incision (dotted line) is performed in the inguinal fold, runs one finger width below the anterior superior iliac spine, and includes the anterior third of the iliac crest.

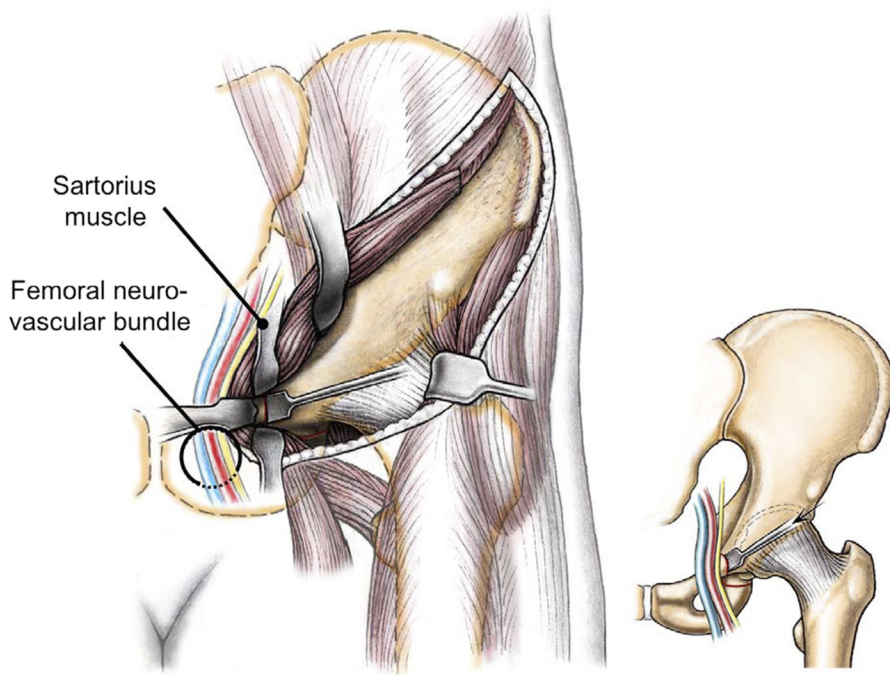


Fig. 3
 A longitudinal incision of the fascia is performed. Care must be taken to not injure the lateral femoral cutaneous nerve, which runs below the inguinal ligament next to the anterior superior iliac spine and continues distally following the sartorius muscle before piercing the fascia.

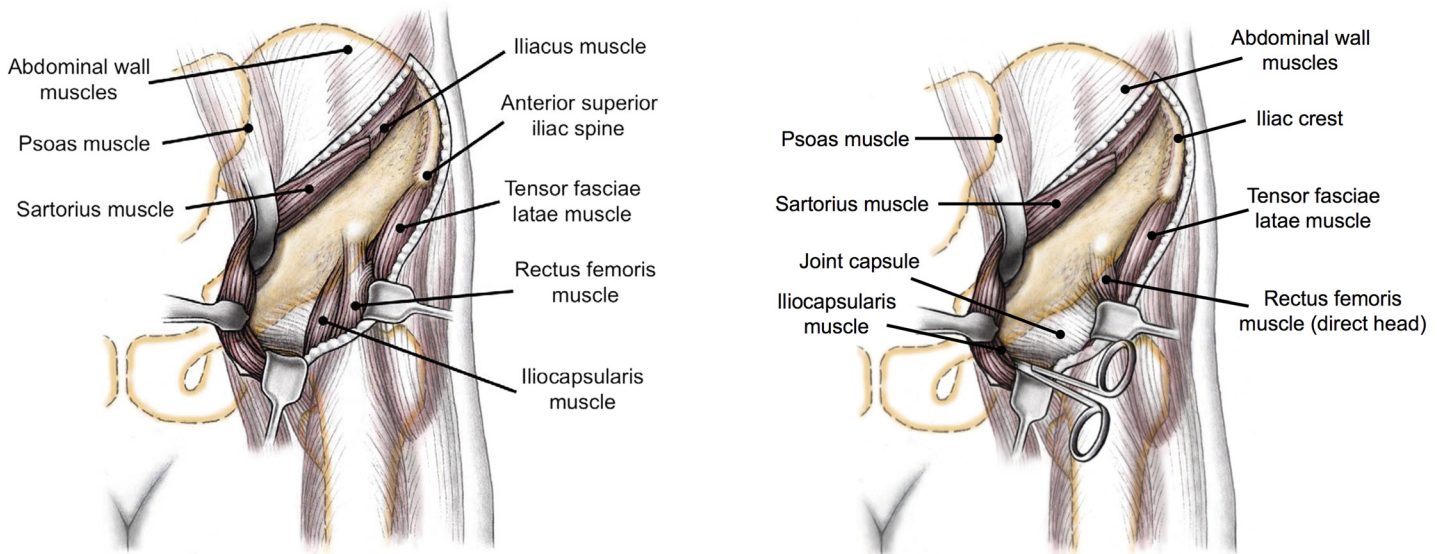


Fig. 4
 The tensor fasciae latae muscle is bluntly mobilized laterally from the fascia, separating this muscle from the sartorius muscle. The lateral femoral cutaneous nerve lies in the fascia of the sartorius muscle. Care must be taken to gently retract the sartorius muscle medially with blunt retractors. The deep fascia is incised longitudinally, exposing the rectus femoris and iliocapsularis muscles. The origins of the sartorius muscle and the inguinal ligament at the anterior superior iliac spine are detached sharply. The abdominal wall muscles are detached from the anterior third of the iliac crest. The iliacus muscle is bluntly mobilized from the iliac fossa.

Fig. 5
 A pointed Hohmann retractor is placed into the superior pubic ramus medial to the pubic eminence. The iliocapsularis muscle is detached sharply from its origin at the capsule and the inferior anterior iliac spine and is retracted medially. This gives access to the infra-articular space, which is spread open with a pair of scissors.

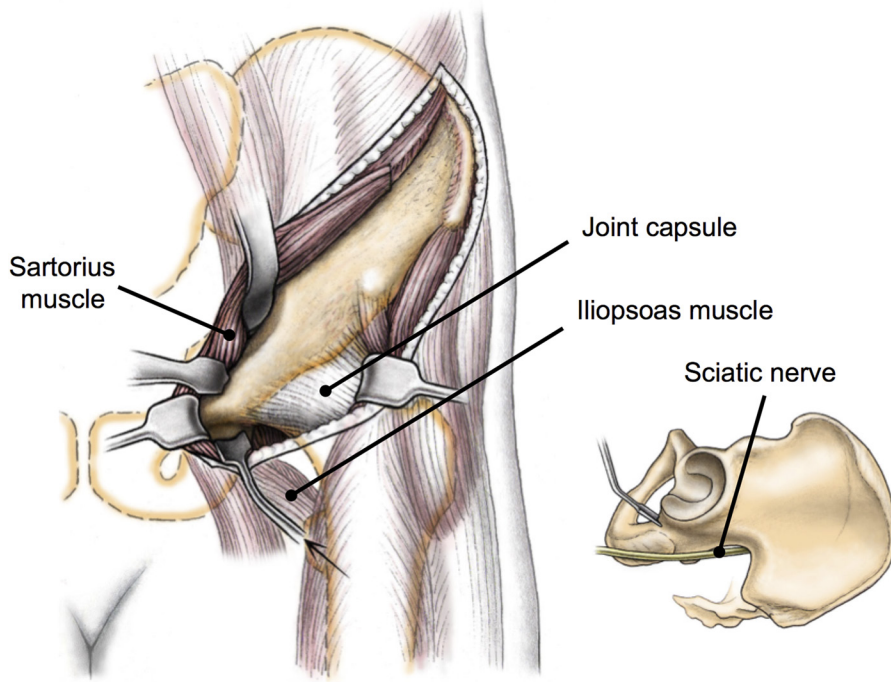


Fig. 6
 The ischial cut is performed with a curved chisel with a crescent-shaped tip. The osteotomy should not exit into the lesser sciatic notch so the posterior column is preserved. Care must be taken to not injure the sciatic nerve, which runs dorsal to the posterior column and in the direction of the osteotomy.

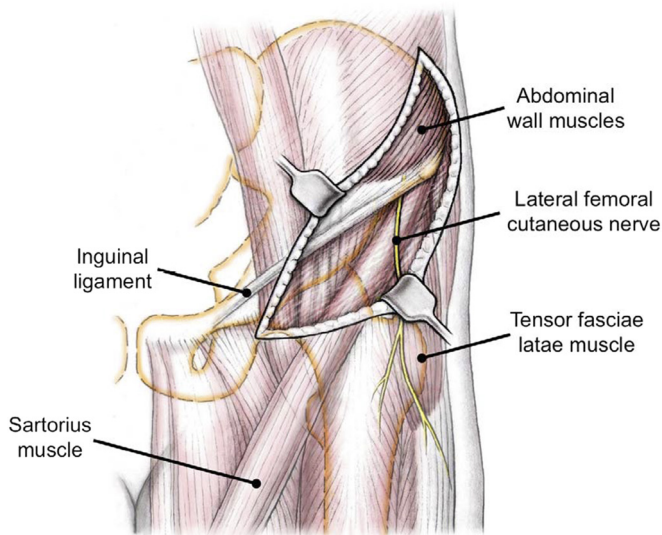


Fig. 7
 To perform the pubic osteotomy, a Hohmann retractor is placed 3 cm medial to the acetabular eminence, retaining the sartorius muscle and protecting the femoral neurovascular bundle. In addition, two blunt curved retractors are placed around the superior pubic ramus. This ensures that the osteotomy is medial to the hip joint and the corona mortis is protected. The osteotomy is performed with a sharp chisel after elevation of the periosteum with a periosteal elevator.

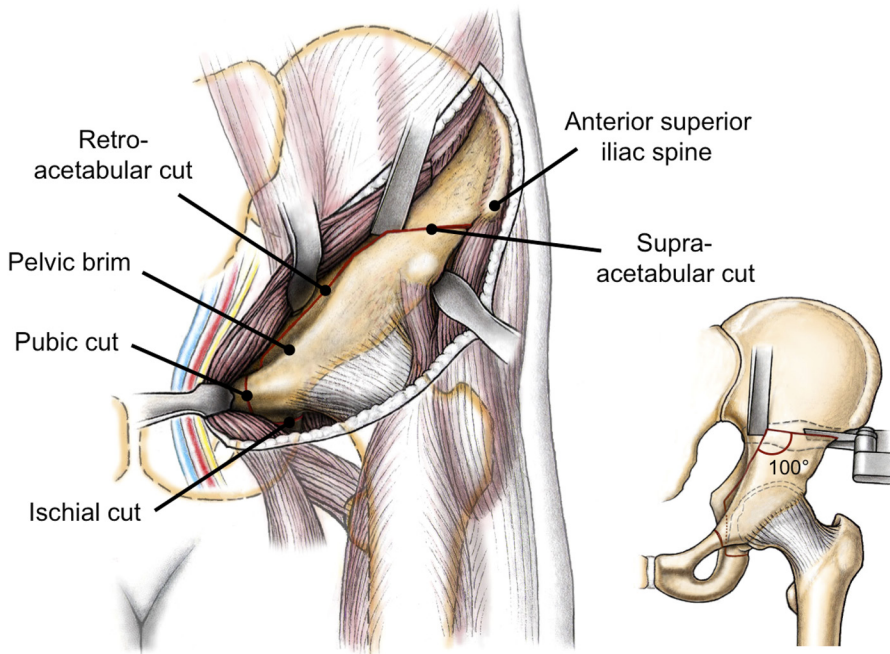


Fig. 8
 After tunneling of the abductor muscles, a curved retractor is inserted to protect the abductor muscles during osteotomy. The supra-acetabular osteotomy starts immediately inferior to the anterior superior iliac spine and ends 2 cm lateral to the pelvic brim. Then, the retroacetabular osteotomy is angled about 100° distally, toward the ischial spine. Ideally, the retroacetabular osteotomy meets the incomplete ischial osteotomy.

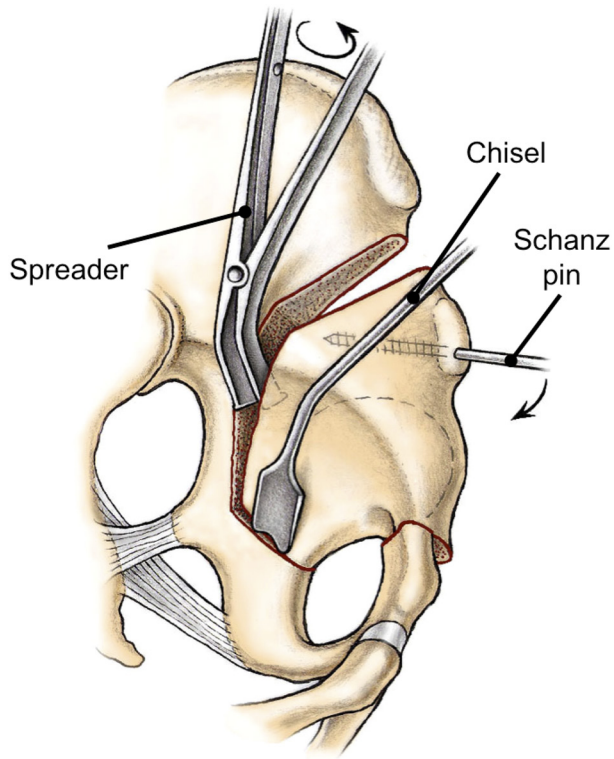


Fig. 9
 A 4.5-mm threaded Schanz pin is inserted into the acetabular fragment at the level of the anterior inferior iliac spine. Remaining bone bridges are fractured with the help of a spreader inserted into the retroacetabular osteotomy site and internal rotation of the fragment with use of the Schanz pin. If the fragment cannot be mobilized, a curved special chisel is used to connect the retroacetabular and ischial osteotomies.

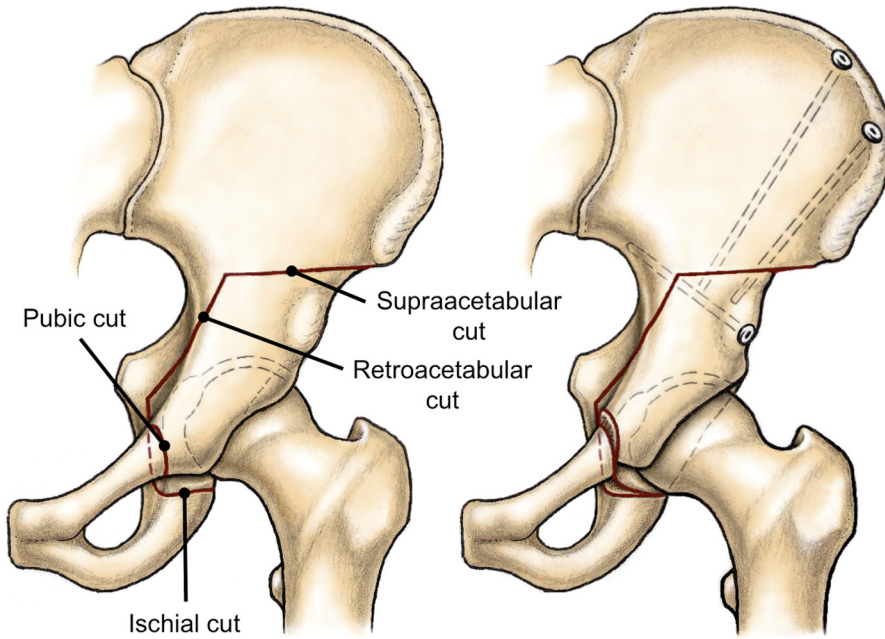


Fig. 10

Internal rotation of the acetabular fragment allows correction of acetabular retroversion. However, with increasing internal rotation of the acetabulum, lateral coverage inevitably increases. When internal rotation would result in excessive lateral acetabular coverage (a lateral center-edge angle of $>30^\circ$), additional flexion of the acetabular fragment with a cranial wedge resection is used to correct acetabular version. The correction is verified intraoperatively on anteroposterior pelvic radiographs. Often, multiple reorientation attempts with repeated radiographs are necessary to achieve an optimal correction. Definitive fixation of the acetabular fragment typically is done with three 3.5-mm cortical screws.

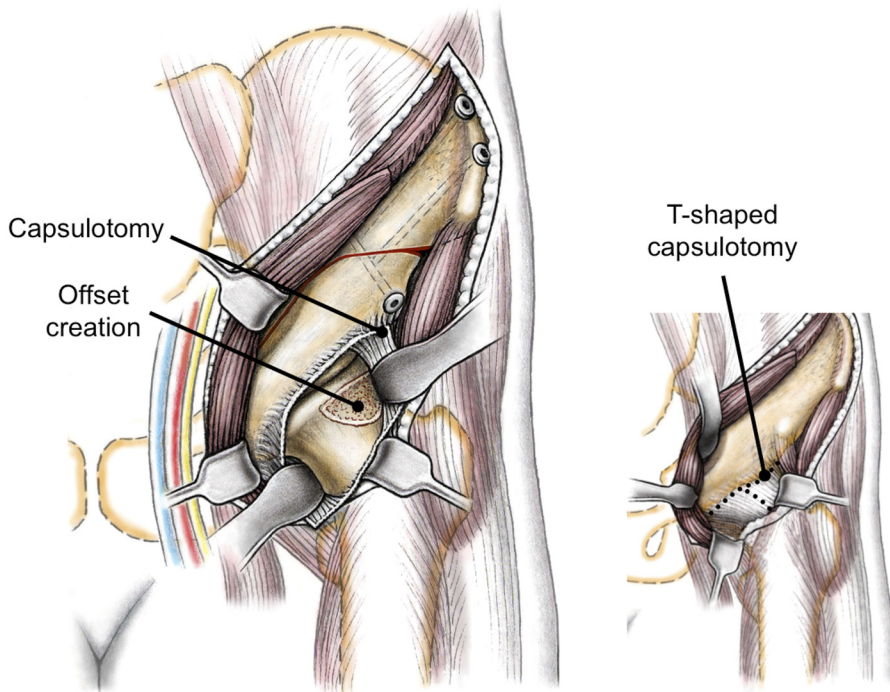


Fig. 11

Intraoperatively, internal rotation in 90° of flexion is tested and should reach a minimum of 30° . If internal rotation remains decreased following acetabular reorientation, a T-shaped arthrotomy is performed. Two blunt retractors around the femoral neck protect the soft tissue while the offset correction is being performed with a chisel and a high-speed burr.

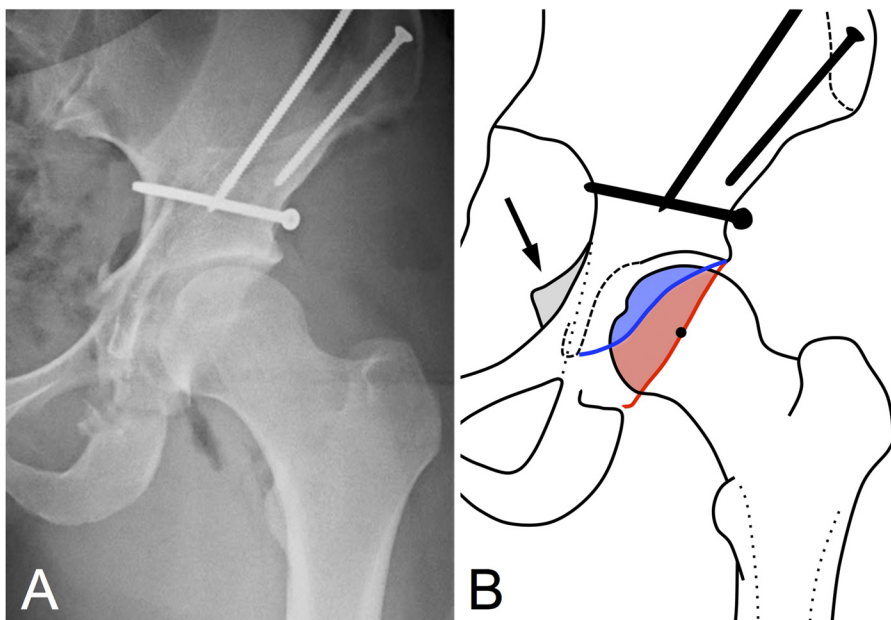


Fig. 12

Fig. 12-A Postoperative anteroposterior pelvic radiograph of a hip with a retroverted acetabulum reoriented by the periacetabular osteotomy. **Fig. 12-B** The anterior acetabular rim (blue) no longer crosses the posterior rim (red); therefore, the crossover sign has disappeared. The posterior acetabular rim (red) no longer runs medial to the femoral head center (black dot); therefore, the posterior wall sign is negative. Typically, the ischial spine sign remains positive following periacetabular osteotomy since the posterior column with the ischial spine remains intact.