

Fig. E-1

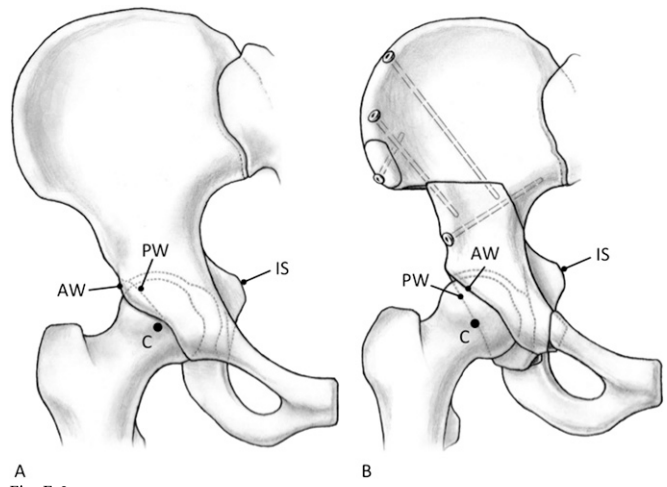


Fig. E-2

**Fig. E-1** The typical radiographic signs of an acetabular retroversion are (1) the crossover sign (the anterior rim is projected more laterally in the cranial portion of the acetabulum and crosses the posterior wall more caudally)<sup>4</sup>; (2) the posterior wall sign<sup>4</sup> (the posterior wall runs medial to the femoral head center [black dot]); (3) the ischial spine sign (the ischial spine protrudes into the true pelvis)<sup>7,8</sup>; (4) a narrow ischium<sup>12</sup>; and (5) a laterally protruding iliac wing<sup>12</sup>. The retroversion index is defined as the quotient between the length of the retroverted zone (a) by the entire length of the acetabulum (b).

**Figs. E-2A and E-2B** A schematic illustration of an anteverting periacetabular osteotomy for the treatment of acetabular retroversion. **Fig. E-2A** The preoperative situation shows the relative anterior overcoverage (positive crossover sign) with a deficiency of the posterior wall (positive posterior wall sign). The ischial spine sign is positive. **Fig. E-2B** The correction with a periacetabular osteotomy is achieved by internal rotation of the acetabular fragment. The posterior column remains intact with a persistently positive ischial spine sign. AW = anterior wall, PW = posterior wall, C = center of the hip joint, and IS = ischial spine.

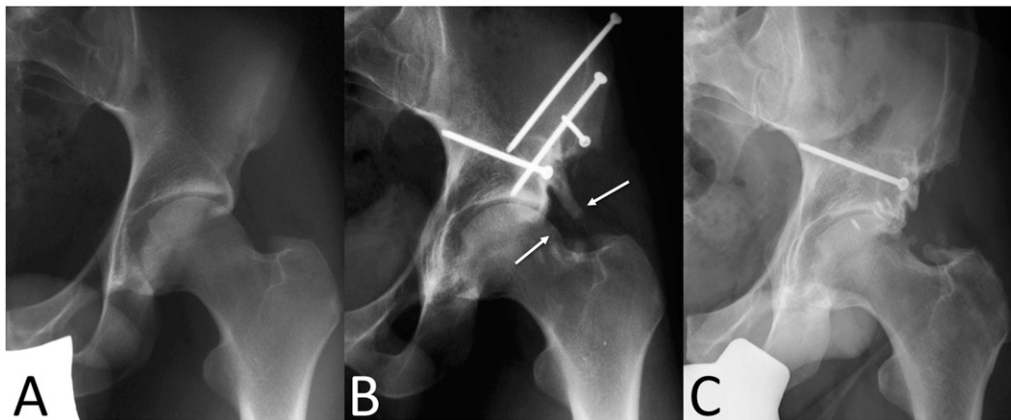


Fig. E-3

**Figs. E-3A, E-3B, and E-3C** A twenty-eight-year-old man with symptomatic acetabular retroversion and a cam-type deformity on the femoral neck. **Fig. E-3A** Preoperative radiograph. **Fig. E-3B** Radiograph made four years after the periacetabular osteotomy, when the patient had persistent impingement pain in the left hip. The radiograph shows a persistent cam type of femoroacetabular impingement as well as heterotopic ossification in the origin of the rectus femoris muscle (arrows). The femoral neck offset was increased, and the heterotopic ossifications were removed with a surgical dislocation of the hip. **Fig. E-3C** At the latest follow-up at ten years after the anteverting periacetabular osteotomy, the patient had an excellent score of 18 points on the Merle d'Aubigné system. The radiograph showed some remaining heterotopic ossification. The joint space remained unchanged compared with the preoperative image (2.3 mm).

**TABLE E-1 Comparison of Preoperative and Postoperative Radiographic Parameters**

| Parameter  | Preop.             | Postop.            | P Value | Description of Parameters  |
|--|--------------------|--------------------|---------|--|
| Lateral center-edge angle <sup>5*</sup> (deg)        | 33 ± 7 (21 to 44)  | 36 ± 8 (24 to 53)  | 0.023   | Angle formed by a vertical line and a line through the center of the head and the lateral acetabular edge  |
| Acetabular index <sup>5*</sup> (deg)                 | 4 ± 5 (−5 to 13)   | 0 ± 5 (−9 to 8)    | <0.001  | Angle formed by the horizontal line and a line through the medial and lateral acetabular edge  |
| ACM angle*† (deg)                                    | 49 ± 3 (43 to 53)  | 47 ± 4 (39 to 53)  | 0.002   | Angle formed between a line from the lateral acetabular edge (A) and the deepest acetabular point (C), and a line from point C to the center of the femoral head (M) |
| Extrusion index <sup>5*</sup> (%)                    | 19 ± 7 (10 to 34)  | 15 ± 9 (−2 to 27)  | 0.016   | Ratio of the uncovered femoral head part to the total femoral head width   |
| Positive crossover sign <sup>4</sup> (no. [%])       | 29 (100)           | 4 (14)             | <0.001  | Crossing of the anterior and posterior acetabular wall with the anterior wall being projected more laterally in the cranial portion of the acetabulum (Fig. E-1)     |
| Retroversion index <sup>5*</sup> (%)                 | 36 ± 12 (16 to 60) | 2 ± 5 (0 to 17)    | <0.001  | Ratio of the length of the retroversion relative to the acetabular diameter (Fig. E-1)   |
| Positive posterior wall sign <sup>4</sup> (no. [%])  | 24 (83)            | 2 (7)              | <0.001  | Is positive when the posterior wall runs medial to the femoral head center   |
| Positive ischial spine sign <sup>7,8</sup> (no. [%]) | 23 (79)            | 14 (48)            | 0.014   | Is positive when the ischial spine protrudes into the true pelvis on the anteroposterior pelvic radiograph   |
| Sharp angle* (deg)                                   | 38 ± 4 (30 to 45)  | 33 ± 5 (22 to 39)  | 0.001   | Angle between a horizontal line and a line connecting the acetabular teardrop with the lateral edge of the acetabular roof   |
| Total superior coverage <sup>5,20*</sup> (%)         | 75 ± 11 (55 to 91) | 84 ± 9 (69 to 100) | <0.001  | Percentage of the femoral head that is covered by the acetabulum in a craniocaudal direction   |
| Total anterior coverage <sup>5,20*</sup> (%)         | 29 ± 8 (16 to 45)  | 21 ± 7 (12 to 37)  | <0.001  | Percentage of the femoral head that is covered by the acetabulum in an anteroposterior direction   |
| Total posterior coverage <sup>5,20*</sup> (%)        | 37 ± 9 (22 to 53)  | 50 ± 12 (34 to 71) | <0.001  | Percentage of the femoral head that is covered by the acetabulum in a posteroanterior direction  |
| Tönnis grade <sup>21†</sup> (no. [%])                |                    |                    |         |  |
| 0  | 29 (100)           | 25 (86)            | 0.06    |  |
| 1  | —                  | 4 (14)             |         |  |
| 2  | —                  | —                  |         |  |
| 3  | —                  | —                  |         |  |

\*The values are given as the mean and the standard deviation, with the 95% confidence interval in parentheses. †Tönnis D. Normal values of the hip joint for the evaluation of X-rays in children and adults. Clin Orthop Relat Res. 1976 Sep;(119):39-47. ‡The Tönnis score could be assessed for twenty-five hips at a follow-up of ten years. Four entirely asymptomatic hips without radiographic follow-up evaluation were rated as grade 0.

### **Surgical Technique**

Basically, the sequence and the orientation of the osteotomies did not differ from the original description<sup>13</sup>. In brief, with use of a modified Smith-Petersen approach, four periacetabular osteotomies and a controlled retroacetabular fracture are performed to mobilize the acetabular fragment. The posterior column remains intact, maintaining the integrity of the pelvic ring and allowing minimal internal fixation of the fragment. Unlike in hips with developmental dysplasia, the acetabular fragment needs to be internally rotated and extended in hips with acetabular retroversion (Fig. E-2). If necessary, a supra-acetabular bone wedge can be removed to allow sufficient extension of the acetabular fragment. Intraoperatively, the accuracy of reorientation of the temporarily fixed acetabular fragment was evaluated with an anteroposterior pelvic radiograph and further repeatedly corrected, if required. The reorientation was deemed optimal if the acetabulum was entirely anteverted and the crossover sign had disappeared (Figs. 1 and E-2). An average of 1.8 intraoperative reorientation attempts (range, one to three attempts) were needed. After acetabular reorientation and final screw fixation, an arthrotomy was performed in twenty-six hips (90%) to check for an impingement-free range of motion and a sufficient internal rotation at 90° of flexion. Typically, an internal rotation of <30° was judged to be insufficient. Subsequently, in twenty-four of the twenty-six hips with an arthrotomy, the femoral head-neck offset was judged to be insufficient and was improved surgically by performing a trimming of the anterosuperior head-neck junction. With the joint opened and traction of the leg, limited evaluation of the acetabular rim lesions could be done. In all twenty-six hips with an arthrotomy, labral degeneration and partial (fifteen hips; 58%) or complete (eleven hips; 42%) undersurface tears of the labrum were detected. In addition, sixteen hips showed alterations of the adjacent cartilage (roughening, tears, and delamination). Except for trimming of two largely degenerated labra with ganglion formations, the chondrolabral lesions were not addressed surgically.