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ORIGINAL STUDY

Treatment of reduced femoral antetorsion by subtrochanteric rotational osteotomy

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The purpose of this study was to assess bone healing and complication rate following subtrochanteric rotational osteotomy fixed with a 4.5/5.0 Locking Compression Plate (LCP, Synthes®) for reduced femoral antetorsion with early full weight bearing. The effects of the osteotomy on the range of internal rotation of the hip and complaints due to reduced antetorsion were also recorded.

Between July 2004 and October 2007, 25 children (39 hips) with a mean age of 13 years (range, 9-18 years) were treated for reduced internal rotation of the hip by a subtrochanteric rotational osteotomy. Four patients (six hips) were excluded from this study due to concomitant surgeries prohibiting full weight bearing.

Of the 21 patients who were allowed full weight bearing, nine had a unilateral and twelve a single-stage bilateral correction. We investigated time to union, implant failure, and complication rate as well as improvement in the range of internal rotation.

All osteotomies healed without secondary displacement or angulation. Internal rotation improved from a mean of 8.6° (-5° to 20°) preoperatively to 37.3° (25° to 60°) postoperatively. We noted no complication related with the femoral osteotomy.

Subtrochanteric rotational osteotomy appeared as a reliable procedure to improve internal rotation of the hip. Fixation with 4.5/5.0 LCP allows simultaneous bilateral correction and immediate full weight-bearing with crutches, with a minimal risk of implant failure.

Keywords : reduced femoral antetorsion ; retrotorsion ; derotation osteotomy ; hip internal rotation.

INTRODUCTION

Femoro-acetabular impingement (FAI) has received much attention during the past decade ; it has been postulated to be an important risk factor for degenerative hip arthritis (*1,5*). It is characterized by a reduced and painful internal rotation and adduction in flexion of the hip, caused by abnormal contact between the femoral head-neck-junction and the acetabular rim (*5*). Typically, patients with FAI become symptomatic with groin pain in early adult age, especially when actively participating in sports. Radiologically, the Dunn view or cross-table projection in internal rotation may detect an aspherical head-neck junction (*8*) responsible for a cam

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impingement (5). In this condition, the femoral head has an increasing radius adjacent to the femoral neck, especially in its anterosuperior part. This part is jammed into the acetabulum during forceful motion, especially with increased flexion and internal rotation. MR arthrography commonly shows labral degeneration or tears, articular cartilage lesions and an aspherical shape of the head at the head-neck-junction in cross-sectional views (6,10). Ganz *et al* described in 2001 the technique including a surgical hip dislocation to correct these deformities (4).

In cases of acetabular retroversion causing FAI, the cross-over sign in the AP pelvic view (11) is positive. In these cases treatment with a periacetabular osteotomy may correct the problem (12).

However, in our younger population radiographs often only show a slightly aspherical or even a normal femoral head. Furthermore the cross-over sign cannot be determined adequately in the immature pelvis because the anterior and posterior rim of the acetabulum are not yet ossified.

Nevertheless, in our outpatient clinic, we frequently see teenagers already complaining of typical clinical signs of FAI. Often, the Dunn view and the physical examination indicate a reduced femoral antetorsion, which can be confirmed by computed tomography. The age-dependent development of the femoral antetorsion during childhood and adolescence is well known. Fabry *et al* (1973) investigated 432 normal children and found antetorsion values of 31 +/- 9° at age 1 decreasing to 15 +/- 8° at age 16 (3). Decreased femoral antetorsion or more even femoral retrotorsion may cause FAI with or without concomitant acetabular retroversion ; Tönnis and Heinecke described in 1991 a diminished femoral antetorsion syndrome as a cause of pain and osteoarthritis and suggested treatment by rotational osteotomy (14). Usually, intertrochanteric osteotomies fixed with angle blade plates are used to correct rotation. This however necessitates partial weight-bearing postoperatively and hinders bilateral one-stage surgery. Using newer angle stable implants for fixation of subtrochanteric rotational osteotomies may facilitate postoperative treatment and allow for early full weight-bearing even in bilaterally operated patients.

The purpose of our study was therefore to evaluate bone healing and complication rate after subtrochanteric rotational osteotomy fixed with the angle stable locking compression plate (LCP, Synthes®), with full weight-bearing allowed postoperatively.

MATERIAL AND METHODS

Patients

Between July 2004 and October 2007, 25 patients (11 girls, 14 boys) aged between 9 and 18 years (mean 13.0 years) with reduced femoral antetorsion were treated with a subtrochanteric rotational osteotomy. Of these, 4 patients were excluded from the present study due to other simultaneous surgery prohibiting immediate postoperative full weight bearing. One patient had a simultaneous arthrodesis in both feet ; one had a triple osteotomy due to secondary hip dysplasia after Perthes disease. The other two patients had a surgical hip dislocation, one for open reduction and internal fixation of the epiphysis because of a slipped capital femoral epiphysis, the other for reshaping of a reduced femoral head-neck-offset. Therefore, 21 patients with a total of 33 osteotomies were included in this retrospective study. Data assessment included a thorough review of the medical records and radiographs. The local ethical committee gave its consent to the study, but no special approval was necessary due to the retrospective character of the study.

Bilateral subtrochanteric derotation was performed in 12 patients. Eight patients, seven of whom had bilateral operations, had typical inguinal pain. Seven patients had pain in the trochanteric region and four complained predominantly of knee pain. Other findings were leg length discrepancy in two patients with concomitant reduced femoral antetorsion of the longer side, and markedly asymmetric rotation of the femur with a consecutive asymmetric positioning of the pelvis and asymmetry during gait. Furthermore, lumbar pain was present in three patients. Three patients, two with bilateral and one with unilateral correction, were asymptomatic. All operated hips had a decreased internal rotation between -5° and 20° (mean 8.6°) with the hip flexed at 90°. Except for the two patients with leg length discrepancy, a CT scan to determine the rotational deformity of the femur and the lower leg were made in all patients. Femoral antetorsion measured between -10° (retrotorsion) and 8° (median 1°).

Three patients had simultaneous interventions during the same anaesthesia : tibial osteotomy (one unilateral, one bilateral) in two patients, owing to increased external rotation of the lower leg, and trochlearplasty in one patient for correction of a marked trochlear dysplasia with patellar instability.

Surgical technique

A lateral subvastus approach to the proximal femur was used. A standard or broad 5- or 6-hole 4.5/5.0 Locking Compression Plate (LCP, Synthes® GmbH, Oberdorf Switzerland) was used for fixation of the osteotomy, depending on the anatomy and weight of the patient. The plate was slightly precontoured and attached with a K-wire through a threaded drill guide in the most proximal and most distal holes, respectively. Fluoroscopic control checked the correct positioning of the plate in respect to the open physis of the greater trochanter. Next, the proximal K-wire was replaced by a fixed angle screw which was only inserted halfway to allow the plate to be rotated out of the operative field when performing the osteotomy. Two 2.5 mm K-wires were then inserted exactly at the angle of the desired correction on both sides of the planned osteotomy which was located at the site of the third plate hole (fig 1). The osteotomy was then performed with an oscillating saw with two subperiosteally placed hook retractors protecting the surrounding soft tissues. Proximally, the fixed angle screw was then brought in completely to fix the plate before the distal fragment was internally rotated until the two 2.5 mm K-wires were parallel. Then, the distal fragment could be attached to the plate with a reduction clamp. At this point, the range of internal and external rotation was checked carefully. After fluoroscopic control to rule out any varus or valgus malpositioning and clinical check of flexion and extension, the osteotomy was definitively fixed. Usually, we used two fixed angle screws proximal to the osteotomy and two or three screws distally. A standard wound closure without suction drain finished the procedure.

Fig. 1. — Determination of correction with 2 K-Wires

Postoperative care

Full weight-bearing with crutches was started on the first postoperative day in most patients. Some patients had to stay in bed for three days due to peridural anaesthesia, one patient had bed rest for one week due to the surgeon's preference. The patient with the trochlearplasty was mobilized in a thigh cast with full weight bearing. The patient with the simultaneous bilateral tibial osteotomies could only be mobilized after two weeks, because of a postoperative compartment syndrome of the lower leg, which necessitated concomitant surgery. Patients were discharged as soon as they were able to ascend and descend stairs with crutches. Mean hospital stay was 9.9 days (range 4-18 days). A first clinical and radiographic check was made after six weeks in all but one patient who had the first check after eight weeks. Twelve patients also had a radiograph three months after the osteotomy. Implant removal was performed in 17 of the 21 patients about one year after primary surgery.

Data assessment : Time to bone healing, the rate of secondary displacement or angulation due to implant failure and change in internal rotation of the hip were assessed.

In contrast to conventional plating techniques with primary osseous healing, the use of angle stable implants normally leads to healing with callus formation. There is no gold standard to define bony union radiographically.

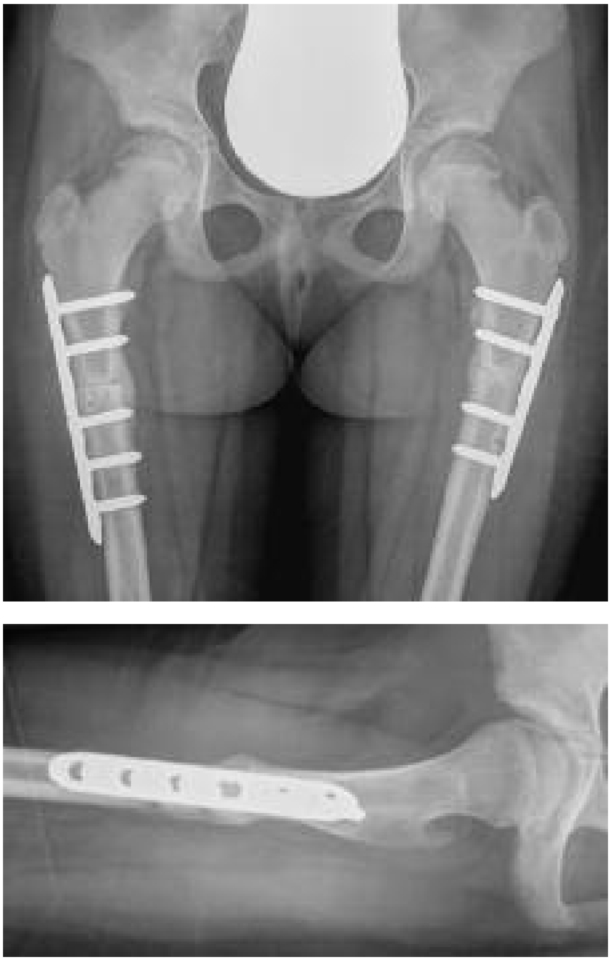

Fig. 2. — Radiographs 6 weeks after operation showing bridging callus in three cortices.

Among the conventional radiographic signs, the number of cortices bridged by bone seems to be an easily measurable and reliable variable to assess bone healing (*10*). Most investigations on this topic were made after intramedullary nailing for tibial fractures ; bony union was defined as bridging callus in two (*2*) or three (*7*) of four cortices. As sometimes only two or three cortices are seen on the radiograph due to the plate being superimposed, we defined bony union to have occurred when bridging callus was present in at least two cortices (fig 2).

Internal rotation was measured clinically with the hips flexed at 90° (table I). The occurrence of complications was assessed by chart review.

RESULTS

All osteotomies healed without secondary displacement or angulation. After six weeks (8 weeks in one patient), all osteotomies showed radiographic signs of at least beginning consolidation.

Seventeen of 33 osteotomies had healed after 6 weeks according to the above mentioned criteria. Of the remaining 16 osteotomies, only 12 had radiographs taken after three months, all of which showed complete consolidation. Two patients with bilateral osteotomies that had not shown complete bone healing after six weeks, only had follow-up radiographs after 7 and 12 months, respectively. Both showed complete consolidation at that time.

Internal rotation improved in all operated hips by 10° to 45° (mean 28.6°) from a mean of 8.6° (-5° to 20°) preoperatively to 37.3° (25° to 60°) postoperatively. From the eight patients with predominantly inguinal pain preoperatively, six had no more pain and two had significantly less pain after a follow-up of 6 to 32 months. In the four patients with predominantly knee pain, two were pain free and two had only minimal pain after a follow-up of 11 to 20 months.

There were two major complications not related to the femoral osteotomy. Both occurred in patients that had other simultaneous interventions. The patient with trochlearplasty developed an incomplete sciatic nerve palsy with complete recovery after a follow-up of one year. The palsy might be attributed to the exsanguination cuff or to a pressure damage from the meniscal brace. A compartment syndrome of the opposite lower leg occurred in one patient with unilateral femoral osteotomy and simultaneous bilateral tibial osteotomies. Fasciotomy was carried out and revealed a hypoperfusion in the anterior compartment. Secondary wound closure could be performed stepwise with intermittent application of a vacuum dressing. After one year, the patient had an extension contracture of the great toe possibly due to scarring of the extensor hallucis longus muscle, but no sign of a drop foot. Therefore, a Z-shaped lengthening of this tendon was performed at the time of implant removal.

Apart from implant removal, no reintervention was necessary in all operated hips. None of the

Table 1. — Patient data

Age gender	Diagnosis	Weight (kg)	IR preop right [1)]	IR preop left [1)]	AT right [2)]	AT left [2)]	IR postop right [1)]	IR postop left [1)]
11y ♀	Femoral retrotorsion both sides	31	10°	10°	0°	-3°	50°	50°
15y ♂	Femoral retrotorsion both sides	53.3	0°	10°	-6°	-4°	35°	35°
18y ♀	Reduced femoral antetorsion right side	48.1	10°	(40°) [3)]	2°	(21°) [3)]	40°	40°
11y ♀	Reduced femoral antetorsion both sides	31	20°	15°	4°	1°	40°	50°
11y ♂	Reduced femoral antetorsion both sides	38.5	0°	0°	0°	8°	40°	40°
12y ♂	Femoral retrotorsion both sides	63	0°	-5°	0°	-4°	30°	30°
13y ♂	Reduced femoral antetorsion both sides	49	10°	10°	5°	7°	40°	40°
10y ♀	Femoral retrotorsion right side	45.4	15°	(40°)	2°	(19°)	40°	40°
13y ♀	Leg length discrepancy (+2.5 cm left side) with femoral retrotorsion left side after femoral fracture	42.9	(40°)	10°	(-)	-	(30°)	30°
9y ♀	Femoral retrotorsion right side with pelvic asymmetry	40	10°	(30°)	-10°	(11°)	30°	(30°)
9y ♀	Reduced femoral antetorsion right side with external rotated gait right side	34.5	10°	(40°)	5°	(11.5°)	35°	(35°)
13y ♀	Femoral retrotorsion both sides	39	0°	0°	6°	4°	30°	30°
15y ♂	Leg length discrepancy (+ 2.7 cm right side) with reduced femoral antetorsion right side	87.3	15°	(35°)	-	(-)	30°	(40°)
16y ♂	Reduced femoral antetorsion both sides	62	20°	10°	6°	1°	30°	30°
16y ♀	Reduced femoral antetorsion both sides	56.1	10°	10°	1°	8°	40°	40°
12y ♂	Reduced femoral antetorsion right side, with impingement, Post-Perthes disease left side	57.5	5°	(30°)	7°	(13°)	40°	(30°)
9y ♀	Reduced femoral antetorsion right side, increased external rotation of the lower leg both sides	22.4	15°	(70°)	4°	(26°)	60°	(60°)
16y ♂	Reduced femoral antetorsion both sides, increased external rotation of the lower leg right side	85	10°	10°	-1°	5°	30°	30°
16y ♂	Femoral retrotorsion both sides	58.5	20°	15°	-3°	-2°	45°	40°
14y ♂	Femoral retrotorsion both sides	79.3	5°	0°	-6°	-4°	35°	25°
15y ♂	Femoral retrotorsion right side and dysplastic trochlea right side	56.5	5°	(25°)	-4°	(8°)	40°	(15°)

1) Measured clinical internal rotation pre- and postoperatively in 90° flexion.
2) Measured antetorsion with CT-scan.
3) Values of those femurs which were not treated are in parenthesis.
(IR : internal rotation ; AT : antetorsion)

patients had significant problems attributed to the implant or the surgical approach.

DISCUSSION

Tönnis and Heinecke described in 1991 a syndrome of diminished antetorsion of the femur as a possible cause of pain and osteoarthritis of the hip and they suggested a treatment by rotational osteotomy (*14*). However, no biomechanical explanation for this observation was given. The mechanism of femoro-acetabular impingement (FAI) was first described in 1999 (*9*). In a group of patients with residual pain and limited range of motion after a Bernese periacetabular osteotomy, MRI studies revealed labral degeneration and adjacent cartilage damage. This was associated with head to rim contact with the hip in a flexed and internally rotated position. Ever since, FAI has been recognized as a common clinical problem. Ganz postulated two types of FAI : cam impingement which is caused by nonsphericity at the femoral head-neck-junction, and pincer impingement by an anterior overcoverage of the femoral head because of a coxa profunda or a retroversion of the acetabulum (*5*). The surgical treatment consists either in a surgical hip dislocation with reshaping the nonspherical portion of the head and/or resection of the anterior overcoverage of the acetabulum. Alternatively, arthroscopic techniques have been developed and are being improved. In cases of severe retroversion of the acetabulum, a reorientation with a periacetabular osteotomy must be performed (*12*).

In our practice, we recognize a growing number of children and adolescents with typical complaints of FAI. Whereas most of them show a normal head-neck configuration almost all have a reduced femoral antetorsion, which also leads to an earlier contact between femur and acetabulum during internal rotation. It seems obvious, that the mechanisms which can cause pain and osteoarthritis in hips with a diminished antetorsion of the femur as described by Tönnis and Heinecke (*14,15*) are the same as those in the FAI described by Ganz *et al.* We therefore believe that the reduced femoral antetorsion should be regarded as a third cause of FAI.

In patients with decreased and painful internal hip rotation, an evaluation of the femoral torsion, femoral head-neck shape and in adolescents with completed ossification of the acetabular rim of the acetabular version is therefore crucial. Based on our experience, we believe that a rotational osteotomy must be discussed with these patients when femoral antetorsion is clearly diminished and an incongruence of the femoral head-neck-offset is radiographically not apparent. A recent MRI-based study (*17*) showed that internal rotation of the hip measured at 90° flexion strongly correlated with the space between the femoral neck and the acetabular rim. This supports the concept, that with a rotational osteotomy of the femur, internal rotation can be increased by the amount of rotation at the osteotomy site.

Our data show that the described technique is a technically simple and safe method to treat patients with FAI caused by reduced femoral antetorsion. A slight overcorrection may be aspired in cases with a moderately decreased acetabular anteversion (*15*). There seems to be no relationship between excessive femoral antetorsion and physical performance (*13*). In the absence of a reduced femoral antetorsion (or after operative correction) and presence of a marked retroversion of the acetabulum with painful reduced internal rotation, we suggest to perform a periacetabular osteotomy at or near the end of adolescence as stated by Siebenrock *et al* (*12*).

Fixation of the subtrochanteric osteotomy with an angle stable implant allows simultaneous bilateral correction if necessary and early full weight-bearing postoperatively. The low contact profile of the LCP preserves periosteal blood supply and theoretically allows more rapid bone healing and reduces the risk of delayed union or non-union. Whereas the LCP acts as an internal fixator allowing some motion between the fragments and thus leading to bone healing via callus formation, stability of conventional plating techniques is based on the frictional force between the plate and the bone. These plates are designed to provide absolute stability resulting in primary bone healing. The goal of osteosynthesis after rotational osteotomy is to retain the fragments in the new position. It is virtually not possible to mould a conventional plate to fit in this situation, because there often is a slight step between the fragments at the osteotomy site, due to the oval cross section of the bone. If the osteotomy is not perfectly perpendicular to the axis of rotation, compression of the osteotomy would necessarily lead to a varus/valgus or flexion/extension deviation of the femoral axis.

A drawback of our study is the retrospective design without a control group. Whether or not the development of osteoarthritis can be prevented by this procedure could only be ascertained by a long term randomized follow-up study. We do not know from our data whether an improvement of groin pain might also be achieved by conservative means. We have observed that some patients with discrete symptoms during physical activities became pain free after stopping the activities leading to pain. However, not all of these young patients are willing to discontinue these activities.

In conclusion, reduced femoral antetorsion may lead to complaints of FAI and may therefore be regarded as a cause of it. In the absence of other causes for FAI, a subtrochanteric rotational osteotomy is a safe and relatively simple procedure to improve internal rotation and alleviate pain. The use of angle stable implants facilitates full weight bearing postoperatively in most cases without a significant risk of secondary displacement or non-union.

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