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# Femoral Derotation Osteotomy in Adults for Version Abnormalities

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## Abstract

**Background:** Version abnormalities of the femur can cause pain and hip joint damage due to impingement or instability. A retrospective clinical review was conducted on patients undergoing a subtrochanteric derotation osteotomy for either excessive anteversion or retroversion of the femur.

**Methods:** A total of 55 derotation osteotomies were performed in 43 patients: 36 females and 7 males. The average age was 29 years (range, 14 to 59 years). The osteotomies were performed closed with an intramedullary saw. Fixation was performed with a variety of intramedullary nails. Twenty-nine percent of patients had a retroversion deformity (average,  $-9^\circ$  of retroversion; range,  $+2^\circ$  to  $-23^\circ$ ) and 71% had excessive anteversion of the femur (average,  $+37^\circ$  of anteversion; range,  $+22^\circ$  to  $+53^\circ$ ). The etiology was posttraumatic in 5 patients (12%), diplegic cerebral palsy in 2 patients (5%), Prader-Willi syndrome in 1 patient (2%), and idiopathic in 35 patients (81%). Forty-nine percent underwent concomitant surgery with the index femoral derotation osteotomy, including hip arthroscopy in 40%, tibial derotation osteotomy in 13%, and a periacetabular osteotomy in 5%. Tibial osteotomies were performed to correct a compensatory excessive external tibial torsion that would be exacerbated in the correction of excessive femoral anteversion.

**Results:** No patient was lost to follow-up. Failures occurred in three hips in three patients (5%): two hip arthroplasties and one nonunion that healed after rerodding. There was one late infection treated successfully with implant removal and antibiotics with an excellent final clinical outcome. At an average follow-up of 6.5 years (range, 2 to 19.7 years), the modified Harris Hip Score improved by 29 points in the remaining 52 cases ( $P < 0.001$ , Wilcoxon signed-rank test). The results were rated as excellent in 75%, good in 23%, and fair in 2%. Subsequent surgery was required in 78% of hips, 91% of which were implant removals.

**Conclusions:** A closed, subtrochanteric derotation osteotomy of the femur is a safe and effective procedure to treat either femoral retroversion or excessive anteversion. Excellent or good results were obtained in 93%, despite the need for subsequent implant removal in more than two-thirds of the patients.

In the surgical treatment of hip disorders, a major cause of failure is either insufficient correction or a failure to fully recognize the underlying deformities causing pain and joint damage.<sup>1-3</sup> One type of femoral

deformity that is still frequently overlooked are rotational deformities of the femur, that is, excessive anteversion or femoral retroversion. These rotational deformities may occur alone or may coexist with acetabular dysplasia<sup>4-6</sup> or various types of hip impingement.<sup>2,5,7-9</sup> Rotational deformities may also be associated with cerebral palsy<sup>10</sup> and labral tears<sup>11</sup> and are not unusual after the fixation of femoral shaft fractures.<sup>12-14</sup>

Excessive femoral anteversion can cause instability, damage of the articular cartilage and acetabular labrum, and eventually osteoarthritis.<sup>15-17</sup> Furthermore, it can cause a decrease in the length of the abductor lever arm,<sup>18</sup> posterior extra-articular impingement,<sup>9</sup> and ischiofemoral impingement.<sup>19</sup> Finally, excessive femoral anteversion may cause increased hip and knee adduction moments, an intoeing gait and patellofemoral maltracking, with resultant knee pain and arthritis.<sup>20-22</sup>

Femoral retroversion, on the other hand, causes damage due to impingement between the femoral neck and acetabulum, which may result in damage to the labrum and articular cartilage, ultimately resulting in osteoarthritis of the hip.<sup>16,23</sup> Other potential retroversion problems include an increased risk of slipped capital femoral epiphysis<sup>24</sup> and susceptibility to a traumatic posterior hip dislocation.<sup>25,26</sup> Residual, untreated femoral retroversion may be a reason why hip preserving surgeries may fail, especially after the arthroscopic treatment of hip impingement.<sup>1-3</sup>

Despite the important role of femoral rotational deformity in the

pathogenesis of hip disease, there is little written about the outcomes of treatment. This article describes the technique and outcomes of a closed, derotation osteotomy of the femur to correct either excessive femoral anteversion or retroversion as part of a hip preservation effort. The question to be answered is whether hip pain as a result of version abnormalities of the femur can be alleviated by this type of surgery.

## Methods

Patients selected for the index procedure had hip pain secondary to increased femoral anteversion or femoral retroversion. Surgery was offered if the patient had failed all nonsurgical treatment measures and if the range of motion aberration correlated with the version abnormality (ie, excessive hip internal rotation with excessive anteversion or a lack of internal rotation associated with femoral retroversion). Patients with coxa vara (a neck-shaft angle of  $<125^\circ$ ) or coxa valga (a neck-shaft angle of  $>140^\circ$ ) were excluded, with the understanding that a varus or valgus derotation intertrochanteric osteotomy would be more appropriate to address the concomitant neck-shaft angulation.<sup>27</sup>

In addition to plain radiographs, all patients underwent preoperative MRI to assess the condition of the articular cartilage and labrum and three-dimensional CT scans to accurately define the anatomic deformities. The measurement of femoral version was performed by the CT technique described by Murphy

et al.<sup>28</sup> All readings and measurements were performed by board-certified musculoskeletal radiologists.

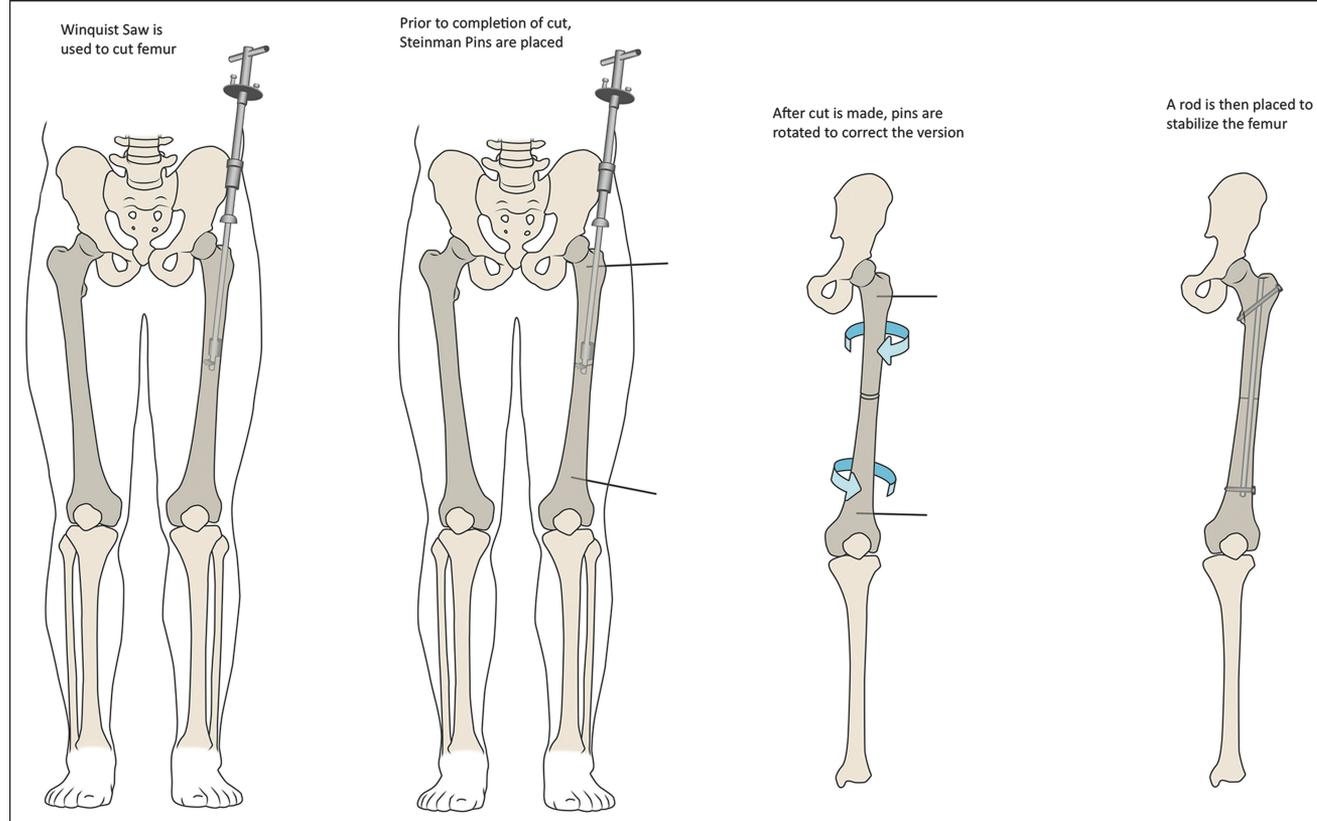
The osteotomies were performed with the patient in the supine position under regional, hypotensive anesthesia. The operated leg was draped free, and traction was not used. An intramedullary hand saw was used that did not require exposure of the osteotomy site.<sup>14</sup> A small, longitudinal skin incision was made just proximal to the greater trochanter. The isthmus of the femur was overreamed by 0.5 mm in accordance with the nail to be used. The subtrochanteric region was then reamed 0.5 mm larger than the diameter of the proposed intramedullary saw. Rotational control was achieved by placing 1/8-inch smooth Steinmann pins into the femur proximal and distal to the osteotomy in the desired amount of rotational correction (Figure 1). The location and progress of the osteotomy were controlled by fluoroscopy (Figure 2). The angular correction was controlled visually by using flat, triangular guides from a blade plate instrument set (Figure 3).

The osteotomy was performed in the subtrochanteric region by inserting the hand saw, which was then rotated in a stepwise fashion with progressive protrusion of the blade from the cam. The distal fragment was then rotated to align the two pins parallel, thus effecting the rotational correction. The goal was to achieve approximately  $15^\circ$  of femoral anteversion. Fixation was then achieved using a variety of trochanteric entry intramedullary nails that were locked proximal and distal to the osteotomy.

Dr. Buly or an immediate family member has stock or stock options held in Blue Belt Technology and serves as a board member, owner, officer, or committee member of the Maurice Mueller Foundation of North America and the International Society for Hip Arthroscopy.

Dr. Rozburch or an immediate family member has received royalties from Stryker; is a member of a speakers' bureau or has made paid presentations on behalf of NuVasive, Smith & Nephew, and Stryker; serves as a paid consultant to NuVasive, Smith & Nephew, and Stryker; and serves as a board member, owner, officer, or committee member of the Limb Lengthening Reconstruction Society. None of the following authors or any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article: Mr. Sosa, Dr. Poultides, and Ms. Caldwell.

Figure 1



Schematic illustration demonstrating the osteotomy technique.

The intramedullary devices used were 42 TriGen Trochanteric Antegrade Nails (Smith & Nephew), five Trochanteric Fixation Nails and three Intramedullary Femoral Nails (DePuy Synthes), four Gamma Nails (Stryker), and one piriformis fossa entry Phoenix Femoral Nail (Zimmer Biomet).

Concomitant hip arthroscopy was performed just prior to the osteotomy if the magnetic resonance image revealed labral and/or articular cartilage lesions or the presence of a cam lesion of the femoral neck that would impinge if a retroverting derotation femoral osteotomy was to be performed for excessive anteversion.

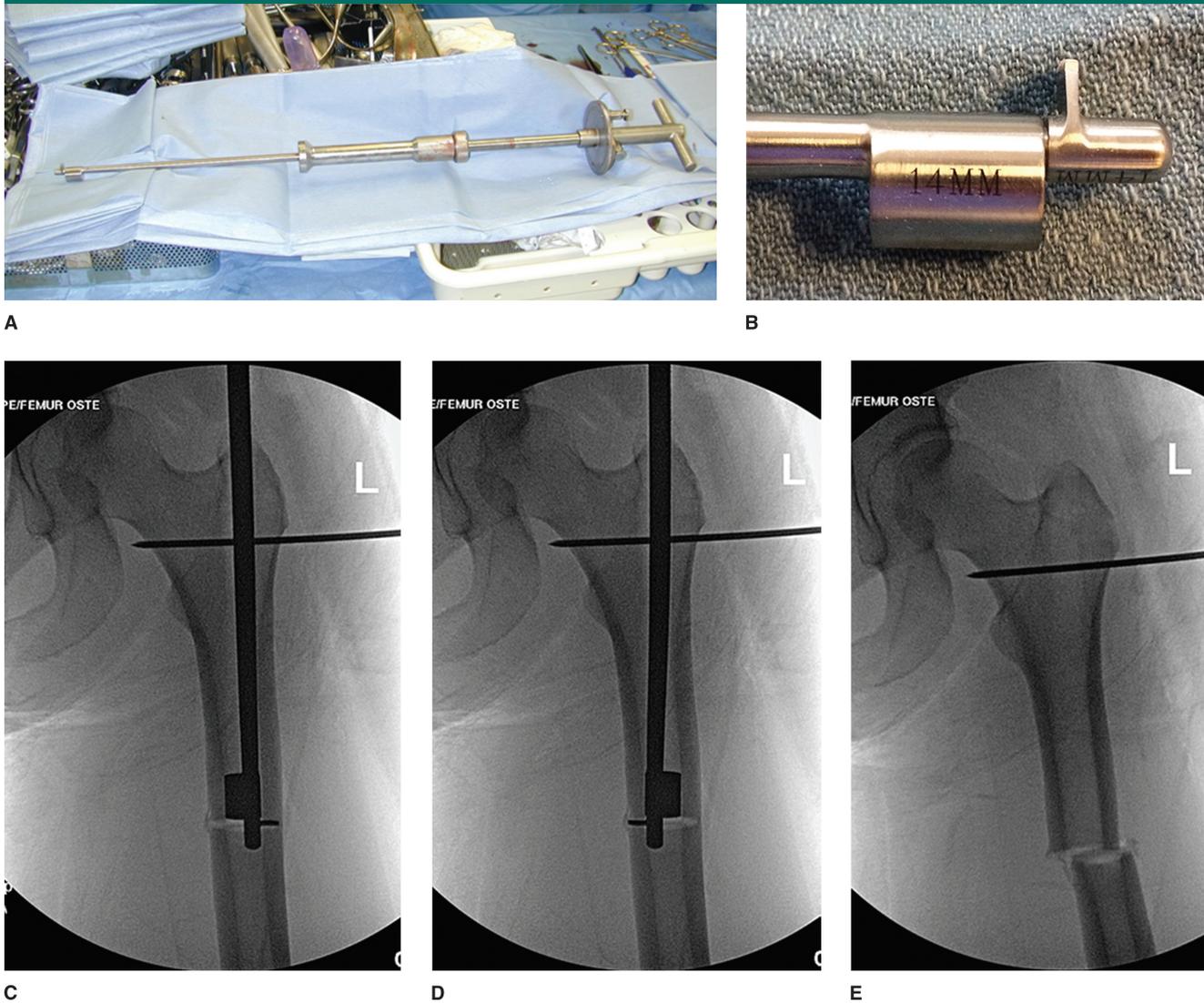
A concomitant periacetabular osteotomy was performed at the same setting if there was coexisting, severe dysplasia that required correction along with the femoral ver-

sion. The periacetabular osteotomy was performed first with the same preparation and drape setup used for both procedures.

A concomitant tibial/fibular osteotomy was performed if the patient had a compensatory external tibial torsion coexisting with excessive femoral anteversion, as described by Tönnis and Heinecke.<sup>15</sup> This procedure was done to prevent an exaggerated external foot progression angle that would result from derotating the excessively anteverted femur in patients with this rotational deformity. The tibia was either internally rotated with gradual correction using an external hexapod frame in the supramalleolar or proximal tibial regions or corrected acutely over an intramedullary nail, depending on the morphology of the tibial deformity.

Postoperatively, epidural patient-controlled anesthesia was used if a tibial osteotomy was not performed. Intravenous patient-controlled anesthesia was used instead with tibial osteotomies to allow monitoring of the lower leg and vigilance regarding a possible compartment syndrome. No braces or casts were used after surgery. There were no range of motion restrictions. Weight bearing as tolerated was permitted with crutches unless a concomitant periacetabular or tibial osteotomy was performed, in which case the weight bearing was restricted to 20% for 6 weeks. Follow-up examinations with AP and lateral radiographs were performed at 6 weeks, 3 months, 6 months, and 1 year after surgery. The modified Harris Hip Score (mHHS) was used, and scores were documented before surgery and at

Figure 2



**A**, Photograph showing the Winquist intramedullary saw. **B**, Photograph showing the saw blade extended from the cam mechanism. **C–E**, Intraoperative fluoroscopic images showing gradual transection of the lateral and medial cortices, followed by osteotomy completion.

the latest follow-up. The minimum follow-up time was 24 months.

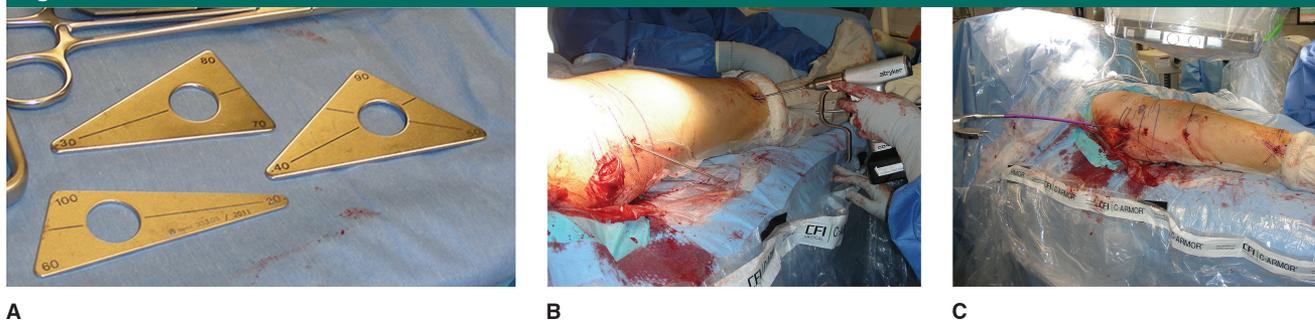
## Results

Starting in 1997, a total of 81 femoral osteotomies have been performed in 67 patients. Forty-three patients having undergone 55 derotation osteotomies had a minimum follow-up of 2 years. All bilateral cases were done staged. There were 36 females

and 7 males; the average age was 29.0 years (range, 14 to 59 years). The deformity etiology was post-traumatic in 5 patients (12%), diplegic cerebral palsy in 2 patients (5%), Prader-Willi syndrome in 1 patient (2%), and idiopathic in 35 patients (81%) (Table 1). All hips had a Tönnis arthritis grade of zero (no evidence of arthritis).<sup>15</sup> Twenty-nine percent of the hips (16 hips in 14 patients) had a retroversion deformity (average,  $-9^\circ$  of retroversion;

range,  $+2^\circ$  anteversion to  $-24^\circ$  retroversion). Seventy-one percent (39 hips in 29 patients) had excessive anteversion of the femur (average,  $+37^\circ$  of anteversion; range,  $+22^\circ$  to  $+53^\circ$  anteversion). The average rotational correction was  $24^\circ$  for the retroverted hips (range,  $18^\circ$  to  $35^\circ$ ) and  $23^\circ$  (range,  $15^\circ$  to  $40^\circ$ ) for anteverted hips (Table 2). All 16 retroverted hips were considered to have “severely diminished anteversion” by the criteria of Tönnis,

Figure 3



**A**, Triangles used to set the degree of rotation correction. **B**, A 20° triangle was used to set the correction between the proximal and distal pins in a case of excessive anteversion. **C**, The femoral nail is inserted while maintaining rotational correction.

whereas 37 of 38 excessively anteverted hips (97%) were considered to be “severely increased” ( $>25^\circ$  of anteversion), with 1 (3%) being “moderately increased” ( $21^\circ$  to  $25^\circ$  of anteversion).<sup>15</sup>

The clinical hip range of motion assessment for all patients included measuring internal and external rotations, with the hip flexed to  $90^\circ$ . Retroverted hips typically lacked or had diminished internal rotation. Conversely, hips with excessive anteversion had more internal rotation than external rotation. For the cases with excessive anteversion, the preoperative average of internal rotation at  $90^\circ$  of hip flexion was  $+73^\circ$  (range,  $+45^\circ$  to  $110^\circ$ ) and external rotation  $+22^\circ$  (range,  $-5^\circ$  to  $+60^\circ$ ). After osteotomy, the internal rotation diminished to  $+26^\circ$  (range,  $+5^\circ$  to  $45^\circ$ ), whereas the external rotation improved to  $+48^\circ$  (range,  $+15^\circ$  to  $70^\circ$ ). This was significant at  $P < 0.01$  (Wilcoxon signed-rank test). For the cases of retroversion, the preoperative average of internal rotation at  $90^\circ$  of hip flexion was  $-1^\circ$  (range,  $-20^\circ$  to  $+10^\circ$ ) and external rotation  $+81^\circ$  (range,  $+50^\circ$  to  $+90^\circ$ ). After osteotomy, the internal rotation improved to  $+23^\circ$  (range,  $+10^\circ$  to  $+35^\circ$ ), whereas the external rotation diminished to  $+42^\circ$  (range,  $+30^\circ$  to  $50^\circ$ ). This was significant at  $P < 0.001$  (Wilcoxon signed-rank test).

Previous surgery had been performed in 26 hips (47%) (Table 1). Twenty-seven hips (49%) underwent concomitant surgery with the index femoral derotation osteotomy, including hip arthroscopy with labral débridement and chondroplasty in 16 (29%), 6 hip arthroscopies with an additional femoral osteochondroplasty (11%), a tibial derotation osteotomy in 7 (13%), and an ipsilateral periacetabular osteotomy with 3 of the femoral osteotomies (5%) (Table 1). Three of the ipsilateral tibial osteotomies were performed in the supramalleolar region and two in the proximal tibia, with external frame fixation. Two of the tibial osteotomies were performed at midshaft with immediate rotational correction and fixation with an intramedullary nail.

No patient was lost to follow-up. One patient died of cancer 12.7 years after surgery with a hip score of 85. The average time to femoral osteotomy union was 3.3 months (range, 2 to 16 months). All the tibial and pelvic osteotomies healed uneventfully.

At an average follow-up of 6.5 years (range, 2 to 19.7 years), the mHHS improved by 27 points ( $P < 0.001$ , Wilcoxon signed-rank test) from 66 to 93 points. When taken separately, there was a statistically significant improvement in both the groups with either retroversion or excessive anteversion (Table 2). The results were rated as excellent in 70%, good in

23%, and fair in 7%, including the revision femoral osteotomy and two total hip replacements.

Failure was defined as conversion to total hip arthroplasty, refixation of the index osteotomy, or an mHHS of  $<70$ . Failures occurred in three hips in three patients (5%): two hip arthroplasties and one rerodding for a femoral nonunion. A total hip arthroplasty was performed 46 months after osteotomy in a 46-year-old woman with Ehlers-Danlos syndrome with only minimal osteoarthritic change seen on MRI and a normal joint space on plain radiographs (Tönnis stage zero). The patient continues to do well with the contralateral osteotomy and has an mHHS of 74 points. Another hip replacement was performed in an 18-year-old man with Prader-Willi syndrome 15 months after the index procedure because of the failure of the concomitant periacetabular osteotomy. The third failure was in a 26-year-old woman with Ehlers-Danlos syndrome with a nonunion that was rerodded successfully. All three presented initially with excessive anteversion.

Subsequent surgery was required in 78% of hips, 39 of 43 (91%) were implant removals. The implant was removed in patients with radiographic evidence of bone union and only if there was notable pain refractory to nonsurgical treatment, usually irritation from the screw heads or a thigh

**Table 1****Summary of Results**

Total patients	43 (36 females and 7 males)
Average age	29.0 y (range, 14 to 59 y)
Total osteotomies	55
Excessively anteverted	39 (71%)
Retroverted	16 (29%)
Etiology (patients)	
Idiopathic	35 (81%)
Posttraumatic	5 (12%)
Cerebral palsy	2 (5%)
Prader-Willi syndrome	1 (2%)
Previous surgery (hips)	
Total	26 (47%)
Hip arthroscopy + femoral osteochondroplasty	13 (24%)
Open reduction + internal fixation	5 (9%)
Previous femoral osteotomy	3 (5%)
Hip arthroscopy + labral débridement	3 (5%)
Femoral lengthening	1 (2%)
Slipped capital femoral epiphysis pinning	1 (2%)
Concomitant surgery (hips)	
Total: all ipsilateral	27 (49%)
Hip arthroscopy + labrum + chondroplasty	16 (29%)
Tibial derotation osteotomy	7 (13%)
Hip arthroscopy + osteochondroplasty	6 (11%)
Periacetabular osteotomy	3 (5%)

ache that occurred with loading or unloading the femur (Figure 4). A revision femoral osteotomy was performed in one hip (2%) by another surgeon to add additional rotational

stability while performing a surgical hip dislocation in a 39-year-old woman with anterior capsular deficiency and instability after four previous surgeries. Currently, 9 months

after the revision femoral osteotomy, the mHHS was 85 points.

A late infection occurred in one femur of a 14-year-old girl 8 months after surgery on the second femur. The organism was a minimally resistant *Staphylococcus aureus* and was treated successfully with implant removal and antibiotics. At follow-up, the patient's mHHS was 100 points.

## Discussion

It has been reported that osteoarthritis may occur with either femoral retroversion or increased anteversion.<sup>15-17,23,29,30</sup> Retroversion of the femur, either alone or in combination with other deformities, can cause hip damage secondary to impingement.<sup>16,23,29,30</sup>

The damage with excessive anteversion occurs at the periphery of the acetabulum secondary to high compressive and shear forces on the articular cartilage and labrum, causing hip pain and arthritis.<sup>15-17</sup> The onset of pain in patients with dysplasia occurs earlier if there is coexistent excessive combined anteversion.<sup>4</sup> Increased femoral anteversion has also been associated with posterior greater trochanteric impingement,<sup>9,31</sup> decreased abductor

**Table 2****Comparison of the Anteverted Versus Retroverted Cases**

Condition	Hips (%)	Periacetabular Osteotomy (%)	Tibial Osteotomy (%)	Average Deformity	Average Correction	Preoperative mHHS	Postoperative mHHS
Excessive femoral anteversion	39 (71)	3 (8)	7 (18)	+37° (+22°±53°)	23° (15°–40°)	64	94 ( $P < 0.01$ ) <sup>a</sup>
Femoral retroversion	16 (29)	0 (0)	0 (0)	–9° (+2° to –24°)	24° (18°–35°)	70	96 ( $P < 0.05$ ) <sup>a</sup>
Total (patients)	55 (43)	3 (5)	7 (13)	—	—	65	94 ( $P < 0.001$ ) <sup>a</sup>

mHHS = modified Harris Hip Score  
<sup>a</sup> Wilcoxon signed-rank test.

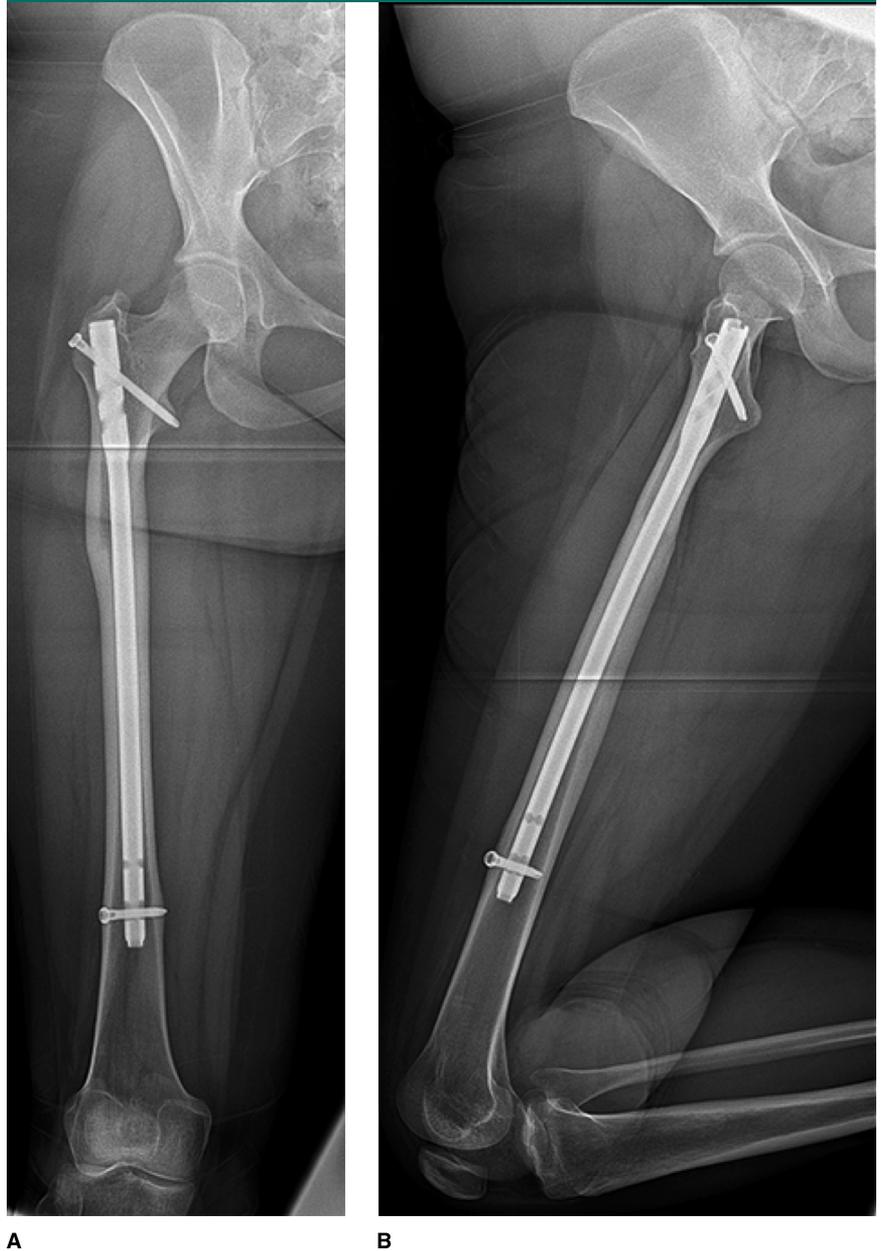
power by <28% due to diminished femoral offset,<sup>18</sup> and hip instability.<sup>32</sup> Psoas irritation may be due to anterior instability; the tendon may act as a dynamic stabilizer and releasing it may exacerbate the problem.<sup>2,33</sup> Patients with symptomatic ischiofemoral impingement with diminished clearance between these two structures are more likely to have excessive femoral anteversion compared to asymptomatic patients.<sup>34</sup> Other problems associated with excessive femoral anteversion include increased hip and knee adduction moments, an intoeing gait and patellofemoral maltracking, pain, and arthritis.<sup>20-22</sup>

The arthroscopic treatment of hip impingement may fail if bony débridement is inadequate. In addition, these procedures may also fail if coexisting femoral retroversion is not detected or treated.<sup>2,35</sup> Six of the patients in this study with retroversion of the femur had previously undergone an arthroscopic débridement with initial symptomatic relief, but eventually had a relapse of painful impingement and a lack of internal rotation.

There is no uniform agreement as to the value of normal femoral and acetabular version. The reported values for the acetabulum range from 13° to 20° of anteversion in three studies, averaging 17°.<sup>30,36,37</sup> For the femur, the range of anteversion is 10° to 20° in three studies, averaging 15°.<sup>15,37,38</sup> The McKibbin index is the sum of acetabular version and femoral version; “normal” is approximately 30°, and values >60° are considered to be highly unstable.<sup>15</sup> The goal of surgical correction was to approach 15° of femoral version. Three-dimensional CT scans were used to measure version as precisely as possible and have long been considered the benchmark technique to measure version.<sup>39</sup>

Version abnormalities of the femur can also be treated with an intertrochanteric osteotomy. These techniques allow the correction of an

**Figure 4**



AP (A) and lateral (B) radiographs of a 17 year-old female who presented with excessive anteversion, showing a healed femoral osteotomy at 12 months postoperatively. The intramedullary nail was subsequently removed.

abnormal neck-shaft angle (ie, coxa vara or coxa valga) and rotational deformities by rotating the distal fragment by the desired amount of correction before applying the blade plate.<sup>27</sup> This technique may not be necessary if the neck-shaft angle is normal, and the only femoral deformity is purely rotational. There is

also no shortening of the abductor muscle fibers as occurs with a varus producing intertrochanteric osteotomy. Because of the much lower profile compared to a blade plate, there can be considerably less peritrochanteric bursitis and pain. A subtrochanteric derotation femoral osteotomy may also be performed by

plating, but it requires a much more invasive approach.<sup>40</sup> The advantage of the described technique is that it allows for a much less invasive approach, lessening surgical morbidity and theoretically a lower chance of infection. In addition, the vastus lateralis is not dissected from the femur, maintaining more of the periosteal blood supply to enhance bone union. In all the cases, it was not necessary to expose the osteotomy site because the transection was performed with an intramedullary bone saw. Other advantages include the ability to allow weight bearing as tolerated immediately because the fixation is provided with a locked intramedullary nail. Placing the distal interlocking screw in the dynamic mode allows compression at the osteotomy site with weight bearing. In contrast, patients treated with an intertrochanteric osteotomy and plating are maintained at 20% weight bearing for at least 6 weeks after surgery. In addition, a pure derotation osteotomy performed in the subtrochanteric region does not deform the proximal femur. Should a total hip arthroplasty be required in the future, it does not hamper stem insertion as can occur after a previous intertrochanteric osteotomy.

The disadvantage of the described technique is that bone healing is slower, averaging 3 to 4 months, and in some cases even longer, which may be due to the diminished healing potential of cortical bone versus cancellous bone. In addition, there is much less surface area at the site of the transverse subtrochanteric osteotomy than with an intertrochanteric or supracondylar type. Another disadvantage is potential damage to the hip abductors because of the reaming necessary to insert a nail. Care was taken to enter the greater trochanter through the posterosuperior “bare area” if possible to leave the abductors minimally disrupted. At

follow-up, no patient had notable hip abductor weakness or Trendelenburg limp or sign.

It was necessary to perform a concomitant tibial osteotomy in seven cases (13%) with excessive femoral anteversion and a compensatory external tibial torsion instead of the usual intoeing gait associated with excessive anteversion, dubbed as “miserable malalignment syndrome.”<sup>21</sup> Surgical correction of increased femoral anteversion requires externally rotating the distal fragment. In these patients, there would have been a greatly exaggerated external foot progression angle.

A concomitant periacetabular osteotomy was performed in patients with severe acetabular dysplasia and coexisting femoral malrotation where it was felt that correction of only one or the other would leave a notable deformity that is often an indication for surgery when occurring alone. This procedure was performed in three patients (5%). Concomitant hip arthroscopy was performed for two reasons: to address intra-articular pathology (ie, torn acetabular labrum and articular cartilage damage) that would ordinarily not be accessed during the osteotomy and to remove a sizable cam lesion that would impinge after a femoral retroverting osteotomy.

The failures all occurred in patients with excessive anteversion and connective tissue disorders: Ehlers-Danlos or Prader-Willi syndrome. Interestingly, failure did not occur in the contralateral osteotomy of the two Ehlers-Danlos patients. Collagen abnormalities associated with these conditions may have contributed to the problems of instability and poor bone healing.

Although subsequent surgery was required in 78% of hips, 93% of these were implant removals. Overall, 70% of patients underwent removal of the implant. Although generally better tolerated than a blade plate after intertrochanteric osteotomy, most patients had either irritation from the in-

terlocking screws or a thigh ache that resolved in most cases after implant removal. Other than the hip arthroplasties or osteotomy revisions, the remainder of cases were hip arthroscopic débridements in two patients.

Winquist<sup>14</sup> reported the ability to perform a closed osteotomy and intramedullary nailing to correct simple rotational deformities.

Chapman et al<sup>13</sup> reported closed osteotomy nailing performed in 31 patients for leg-length inequality and 6 with rotational deformities. Preoperative rotational deformities averaged 58° and all were corrected to within 5° of normal.

Stahl et al<sup>12</sup> treated 14 patients with posttraumatic rotational deformities of the femur that ranged from 26° to 63° with a closed technique over an intramedullary nail. Postoperative CT scans revealed excellent correction of the deformity within 4° in all cases.

Kamath et al<sup>40</sup> reported 28 rotational femoral osteotomies in 26 patients, 93% for excessive femoral anteversion. Clinical outcomes were not reported. After two initial failures for nonunion, all subsequently went on to union with refixation.

Pailhe et al<sup>41</sup> reported nine derotation osteotomies in six adolescents (average age, 13.6 years) for excessive anteversion. The technique was done with a distal supracondylar osteotomy and fixation with an antegrade intramedullary nail. The average correction was 19°. Patient-reported outcome scores were not recorded. All patients were satisfied or very satisfied and had better foot progression angles and less internal rotation on range of motion testing.

Putz et al<sup>10</sup> performed 96 derotation femoral osteotomies (proximal or distal) in 63 adult cerebral palsy patients with excessive anteversion. Although patient-reported outcome scores were not recorded, the group experienced statistical improvement in foot progression angle and passive and stance range of

motion. Tibial rotation osteotomy was required in 16.7% of cases to compensate for excessive external tibial torsion.<sup>10</sup> In the present study, a similar need for concomitant tibial derotation osteotomy was noted.

The limitation of this study is that it is a retrospective case series without a control group. However, it is a single-surgeon series with a consistent technique over a 20-year period. The present study seems to be the only series in which a patient-recorded outcome score was used. In addition, no patients were lost to follow-up.

## Conclusion

In conclusion, hip pain and deterioration can be caused by a variety of deformities, acting either alone or in combination. There can be considerable overlap with acetabular dysplasia, hip impingement, and neck-shaft abnormalities, while femoral version may be diminished, normal, or excessive. It is important to identify all the deformities present to ensure the best chance of success after hip preservation surgery. Version abnormalities of the hip, often overlooked, must be assessed because of the damage caused by these deformities. A closed, subtrochanteric derotation osteotomy of the femur is a safe and effective procedure to treat either femoral retroversion or excessive anteversion. Excellent or good results were obtained in 93%, with a statistically significant improvement in the mHHS, despite the need for subsequent implant removal in more than two-thirds of the patients. Failures may occur in patients with genetic defects associated with abnormal collagen or bone density.

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