

Percutaneous Femoral Derotational Osteotomy for Excessive Femoral Torsion

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Abstract: Femoral derotational osteotomy is an acceptable treatment for excessive femoral torsion. The described procedure is a minimally invasive single-incision technique based on an intramedullary saw that enables an inside-out osteotomy, preserving the periosteum and biological activity in the local bone and soft tissue. After the osteotomy is complete and correction is achieved, an expandable intramedullary nail is used to achieve immediate stability, without the need for locking screws. Indications, tips, and pitfalls related to this novel osteotomy technique are discussed. [*Orthopedics*. 2014; 37(4):243-249.]

Developmental dysplasia of the hip can present as various morphological abnormalities. The acetabulum of a dysplastic hip typically is characterized by a shallow articulating cavity, an excessively oblique acetabular roof, and

decreased acetabular coverage of the femoral head.¹ Other patients may present with an increased femoral anteversion.² Femoral version is defined as the angular difference between the axis of the femoral neck and the transcondylar axis of

the knee. In most adults, anteversion averages between 10° and 15°. Abnormal femoral torsion may cause abnormal joint stresses, leading to subsequent degeneration of the labrum and articular cartilage, hip pain, and secondary osteoarthritis at an early age.³ Complaints can range from posterior (buttock) pain due to ischiofemoral impingement (short lesser trochanter to ischial tuberosity distance) to anterior hip pain and labral tears as the forward facing femoral head places excessive stress on the iliopsoas and labrum.⁴

Femoral derotational osteotomy is an established treatment for patients with symptomatic excessive anteversion of the femur.⁵ The goal of the surgery is to correct the anteversion to a normal value, reducing the stress on the joint and therefore secondary pain and degeneration.⁶⁻¹⁰ During the procedure, the increased anteversion is normally corrected by rotating the distal fragment externally.

Osteotomies can be performed in an open or closed

manner. Closed, or “inside-out,” intramedullary osteotomies preserve the bony periosteum and prioritize blood supply and biological activity to promote faster fracture healing, having the additional advantage of eliminating the need for a second incision and its associated morbidity.¹¹⁻¹⁸

In an open osteotomy, an oscillating saw, gigli saw, or chisels are commonly used. Open osteotomy, in general, carries a higher risk of infection as well as a higher risk of delayed or nonunion secondary to damage to local soft tissue and periosteal stripping. To preserve the periosteum and the biological activity of the bone and soft tissue in the area of the osteotomy, an intramedullary saw was developed, allowing an inside-out femoral osteotomy for correction of these rotational deformities.¹⁴

Various methods have been described to stabilize the bone fragments once the derotational osteotomy has been performed.^{6,15,16} The Fixion nail (Carbofix Orthopedics,

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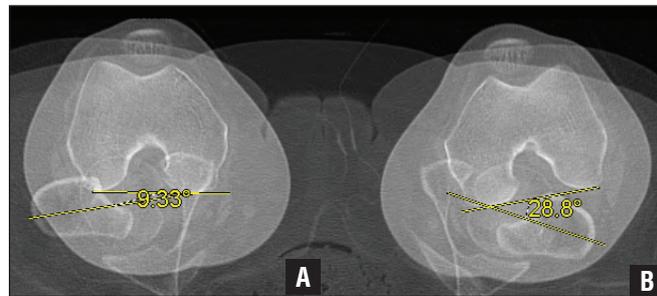


Figure 1: Computed tomography axial cuts. Preoperative computed tomography scans allow measurement of the bilateral femoral version. Femoral anteversion is the angle between the transverse axis of the knee joint, which is best indicated by a line drawn tangential to the maximum posterior convexity of both femoral condyles, and the transverse axis of the femoral neck. Femoral anteversion of 9.3° (A). Femoral anteversion of 28.8° (B).

Herzeliya, Israel), described in this technique, is an expandable, stainless steel cylindrical nail folded longitudinally in a specially designed press.^{17,18} The nail is designed to be inserted with or without reaming and is then expanded up to approximately 175% of its original diameter, using highly pressurized normal saline (up to 70 bars). After expansion, the nail abuts the inner surface of the medullary canal along its entire length, making interlocking unnecessary. This allows operating times to be reduced, additional skin incisions to be eliminated, and exposure to ionizing radiation to be minimized. Previous reports have described the successful use of the Fixion Nail for the treatment of femoral shaft fractures^{17,19}; however, use of this device for derotational osteotomies, with a single-incision technique, has not yet been described. The authors present this technique and discuss indications, tips, and pitfalls related to its use in femoral derotational osteotomies.

PREOPERATIVE PLANNING

A diagnosis of excessive femoral torsion is made using detailed clinical and radiographic examinations.

Clinically, patients may report anterior hip pain, psoas tendinitis, and buttock pain secondary to ischiofemoral impingement. Examination in the prone position is used to assess hip joint range of motion in neutral hip position (0° flexion/extension). Patients with anteverted femurs normally present an excessive internal rotation of the hip with the knee bent to 90° in the prone position. Noting the position of the patella, an accurate determination of the femoral anteversion can also be made. In the clinical examination of the rotational profile of patients with excessive femoral anteversion, the patella will be pointed inward with the feet parallel.

Standard radiographic analysis, including true anteroposterior pelvis, cross-table lateral, and/or Dunn views, is performed to assess for concurrent pathologies such as femoroacetabular impinge-

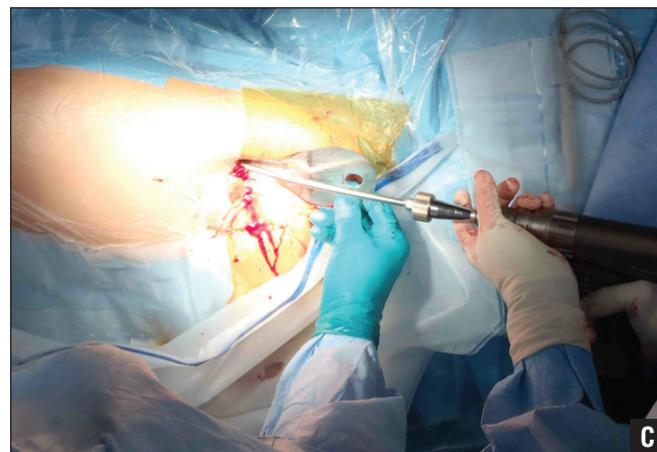
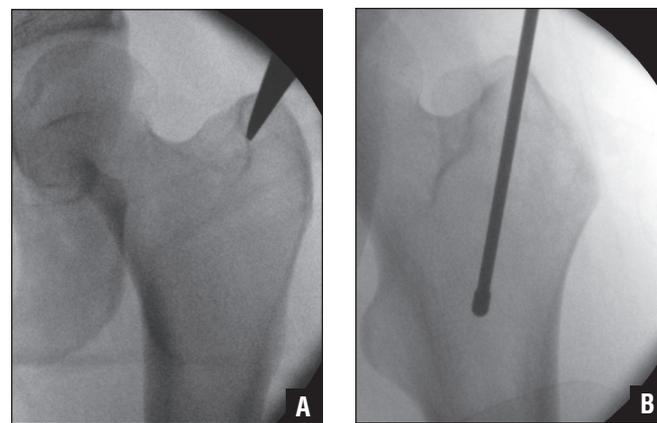


Figure 2: Fluoroscopy showing a femoral derotational osteotomy. Anteroposterior intraoperative views of an awl on entry point at the tip of the greater trochanter (A) followed by introduction of a ball-tipped guidewire (B). Intraoperative photograph showing reaming of the medullary canal (C).

ment, dysplasia, or posterior (ischiofemoral) impingement.

The authors use computed tomography (CT) scan with 3-dimensional reconstruction including both femoral neck and distal femoral condylar axial views to obtain femoral torsion measurements, as well as full-length scanogram to assess for possible leg-length discrepancy. In cases of clinical suspicion for pathological tibial torsion, CT views are extended to the proximal tibia and ankle measurements. External torsion of the tibia is a clinical finding

that is observed frequently, although not consistently, in patients with increased femoral anteversion.⁴

The amount of correction is determined on the basis of preoperative radiographs and CT scans (**Figure 1**). Contralateral anteversion of the femur should also be assessed. The surgical team determines the rotational correction necessary based, in part, on the patient's contralateral version, as well as physiological version of approximately 15° to 20°. The goal is to achieve 15° to 20° of anteversion. However, because

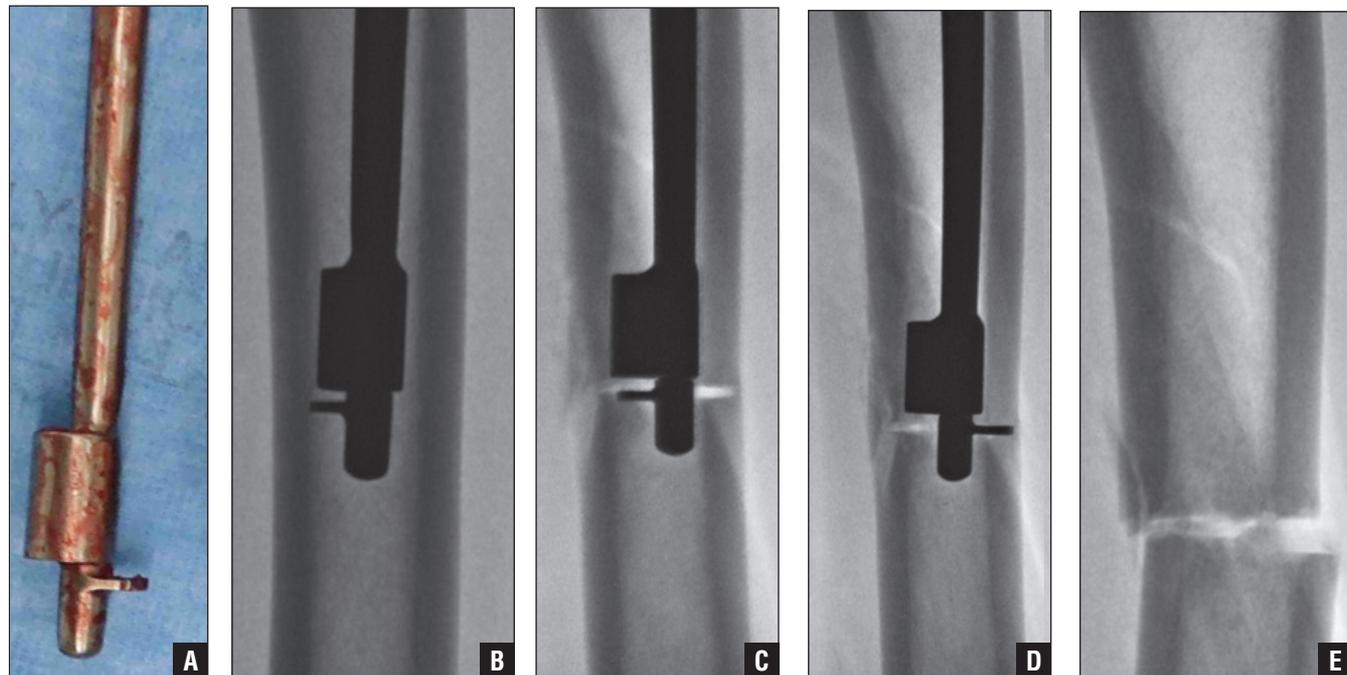


Figure 3: Under fluoroscopy, the osteotomy is performed using the intramedullary saw (A). Under C-arm, the intramedullary saw is introduced into the femoral canal and seated at the planned level of the osteotomy (B). The saw diameter is then increased incrementally and rotated within the femoral shaft in fine clockwise movements, performing a circumferential inside-out cut in the femur (C, D). Note the complete osteotomy performed once the intramedullary saw is removed (E).

currently inadequate intra-operative measurement tools exist for assessing rotational correction, the authors aim to correct to under 30° because it is less than 2 SDs from the normal range.

The osteotomy is normally performed 4 to 6 cm below the lesser trochanter, where the diameter of the femur becomes thinner.

SURGICAL TECHNIQUE

The patient is positioned supine on a fracture table or hip arthroscopy distraction table. In some cases, hip arthroscopy may be required immediately prior to the derotational osteotomy because of concurrent intra-articular pathology. In this instance, the authors use a single prep and draping setup for both procedures. Draping starts

proximally at the iliac crest and spans the entire femur, ending inferior to the knee joint (**Figure 2**). A 4- to 5-cm incision is made proximal to the greater trochanter, similar to antegrade femoral nailing for fractures. Using an awl, an entry point is established at the tip of the greater trochanter and a ball-tipped guidewire is introduced (**Figure 1**).

Reaming is then performed starting with an 8-mm reamer, in 0.5-mm increments, to open the medullary canal and accommodate the intramedullary saw used to osteotomize the femur. In general, these intramedullary saws can be expanded to 180% of their original diameter. The authors usually ream proximally to 15 mm using a 15-mm saw blade allowing a 26-mm cutting di-

ameter. The most common nail they use is 34 to 36 cm long with a diameter of 12 mm prior to inflation. Reaming is performed just 1 cm distal to the planned level of the osteotomy, 5 to 7 cm distal to the lesser trochanter. If a larger nail diameter is to be used and the medullary canal is measured to be narrower than the nail, reaming should be carried further distally, to 0.5 mm greater than the original nail diameter.

Once reaming is complete, the intramedullary saw (Biomet, Warsaw, Indiana) is introduced into the femoral canal and seated at the planned level of the osteotomy. No guidewire is used at this stage. The saw diameter is then increased incrementally (typically 10% at a time) and rotated within

the femoral shaft in fine clockwise movements, performing a circumferential inside-out cut in the femur (**Figure 3**). Once several full circles are completed, and the surgeon feels minimal to no bony resistance on the blade, further increase in the diameter of the blade is performed, until a complete, or a near complete, osteotomy is achieved. The saw blade is opposed to the cortical bone via a surrounding cam device that stabilizes the cutting complex within the canal and maintains a precise, horizontal cut. Just prior to completion of the osteotomy and confirmation of displacement, 2 Steinman pins are drilled—1 at the lateral greater trochanter and 1 at the supracondylar region of the distal femur—with the guidance of fluoroscopy. Us-

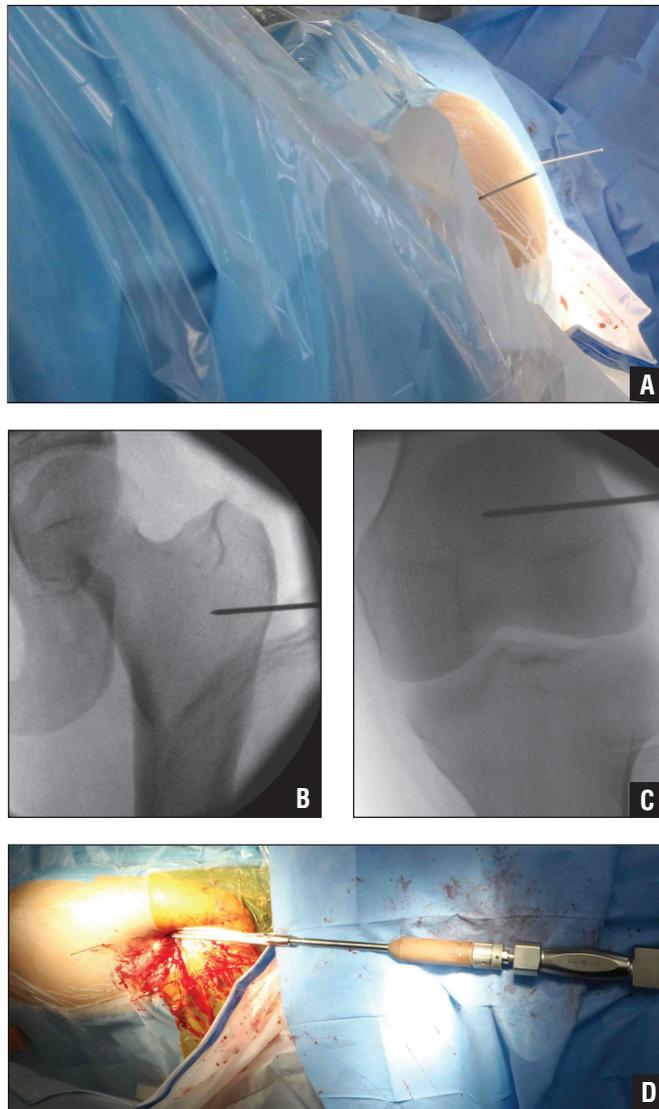


Figure 4: Intraoperative photograph (A) and fluoroscopic images (B, C) showing the pin placement allowing assessment of rotation. Anteroposterior view of the hip. The proximal pin is located at the greater tuberosity (B). Anteroposterior view of the distal femur. The distal pin is located above the lateral epicondyle (C). Photograph showing nail insertion (D).

ing fluoroscopy and the angle between the Steinman pins, measured with a sterile goniometer, the varus and derotational aspects of the planned osteotomy are performed. Relative retroversion correction of excessive femoral anteversion (torsion) is achieved by rotating the distal femur (at the foot) outward, in relation

to the proximal femur. The correction planned is usually 10° varus (when the neck shaft angle is larger than 140° and the acetabulum has dysplastic or borderline-dysplastic characteristics) and a minimum of 30° of external rotation (to achieve relative retroversion) (Figure 4). An expandable Fixion nail is then introduced

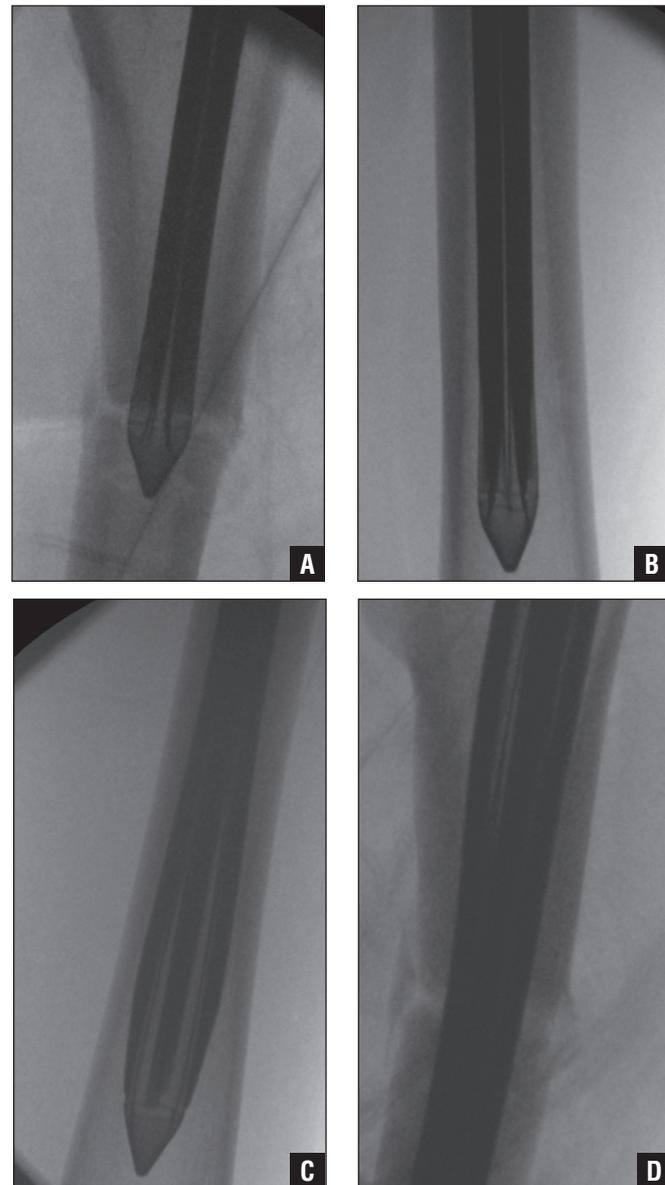


Figure 5: Anteroposterior fluoroscopic image showing the Fixion nail (Carbofix Orthopedics, Herzeliya, Israel) passing the osteotomy prior to expansion (A). Fluoroscopic image showing the Fixion nail at its distal point where the medulla opens up (B). Fluoroscopic image showing the nail fully expanded at its distal point and having good intramedullary purchase (C). Fluoroscopic image 6 weeks postoperatively showing the expanded nail proximally and through the osteotomy with periosteum callus formation (D).

similar to any antegrade femoral intramedullary device, but without the use of a guidewire because the Fixion nail is not cannulated. Once the nail is seated in the femur with the proximal portion flush with

the greater trochanter tip and the distal end at the exit of the femoral isthmus, the nail is expanded with a saline-filled pump to obtain “press-fit” intramedullary purchase (Figure 5).

Postoperative radiographs are obtained to confirm position and location of the nail and alignment. The Steinman pins are removed and the single skin incision is closed (**Figure 6**). Postoperatively, patients are permitted to ambulate partial weight bearing with crutches for 6 weeks. Physical therapy is started immediately, concentrating on passive and active-assisted motion with initiation of isometric activity of the thigh musculature. Patients progress to full weight bearing within 4 to 6 weeks according to subjective recovery and radiographic evidence of bony healing.

DISCUSSION

Femoral derotational osteotomy for excessive femoral anteversion has been described in the literature. However, the literature is vague, subjective, and occasionally contradictory.²⁰

Careful evaluation of each patient before surgery is crucial to obtain optimal results. Physical examination, along with radiographic and CT evaluation, is vital to correct diagnosis and appropriate preoperative planning.

The technique described here represents an efficient and elegant way to obtain this correction and stabilize the resultant osteotomy, achieving rapid healing and return to activities of daily living. The goal of the surgery is to achieve 15° to 20° of femur anteversion. This is obtained by rotating the distal fragment externally. However, current intraoperative measurement

techniques need refinement. Therefore, the authors do not correct excessive anteversion if the anteversion is less than 30° because this is near normal range and the accuracy of surgical correction within a tight range is difficult to predict.

Performing the osteotomy closed²¹ helps preserve the biological activity in the bone and soft tissue in the area of the osteotomy. Intramedullary sawing has been well described in the literature. Kuentscher¹⁴ designed and developed an intramedullary saw that has yielded excellent long-term results.^{11,21,22} Itoman et al²¹ developed a different motor-driven saw to achieve closed intramedullary osteotomy of the femur and tibia, followed by subsequent interlocked nailing. These authors reported good long-term results in a series of 10 patients.

Fixation of the osteotomy has been performed with various implants. Most of the published studies have employed intramedullary rods, AO plates, or dynamic hip screws.²⁰ Plates can be applied with indirect reduction techniques and designed as “biologic” implants (eg, the low-contact dynamic compression plates), but they usually destroy at least some of the periosteal blood supply and disrupt the hematoma. Intramedullary rods have the advantage of preserving the periosteal blood supply and soft tissue, increasing the odds of union and decreasing the odds of infection. Biome-

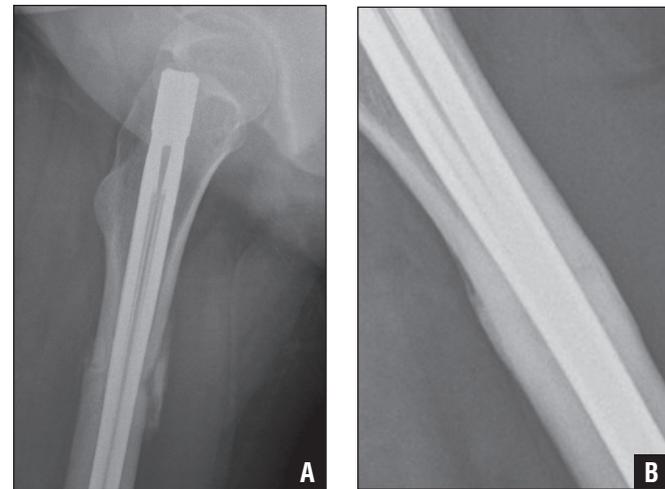


Figure 6: Lateral radiograph obtained 6 weeks postoperatively. Note the osteotomy healing with periosteum callus (A). Lateral radiograph obtained 12 months postoperatively. Note the osteotomy healed (B).

Table 1

Comparison of Intramedullary Nails With Fixion Nails	
Intramedullary Nails	Fixion Nails ^a
Distal locking screws	No distal locking screws
Reaming	No reaming necessary
Increased exposure to radiation	Reduced exposure to radiation
Additional skin incisions for distal screws	One skin incision
Three-point fixation	Homogeneously shared forces

^aCarbofix Orthopedics, Herzeliya, Israel.

chanically, the intramedullary position of the rods offers more resistance to torque forces and increases load transfer to the bone.²³

The authors have described the use of the Fixion nail. The concept is similar to that of the intramedullary rod. However, the Fixion nail is designed to be inserted with or without reaming and is then expanded to approximately 175% of its initial diameter, using highly

pressurized normal saline. Advantages of this nail compared with a standard intramedullary nail are listed in **Table 1**. Also, when using an intramedullary nail, proximal and distal locking screws used with these rods may produce some discomfort. Some patients may report greater trochanter bursitis secondary to the proximal screws, and distal locking screws may be located intracapsularly, producing knee pain and

Table 2

Technical Pearls

For the intramedullary saw

- Patient is placed supine on a traction table
- C-arm is positioned to enable smooth motion between proximal and distal femurs
- Assess exact entry point under C-arm so intramedullary saw can be placed correctly (just lateral to piriformis fossa)
- Reaming should avoid thinning of the anterior cortex
- Reaming starts at 8 mm and advances in 0.5-mm increments until required diameter is achieved
- Use the saw with the largest diameter that can be accommodated by the medulla, making sure after reaming that it is tight but never forced. Advance the saw in a gentle oscillating motion.
- Once in position, increase saw diameter to expose the blade, starting in small increments. The blade is advanced slowly until the indexing device reaches number 20 (which indicates maximum cutting diameter). Remember to return the blade to a closed position and remove the saw to introduce a larger diameter saw if needed.
- If the saw did not complete a circumferential osteotomy but most of the cortex at 1 side (usually medial) is complete, the osteotomy can be completed manually with a gentle lateral to medial direct force to the skin at this level.
- Once the osteotomy is complete, 2 pins are drilled (vastus ridge at the greater trochanter area and epicondyle area of the knee). Accurate placement of the guide pin is important to judge accurate correction.
- Perform the derotation correction (distal fragment should be externally rotated) via an external rotation motion of the foot, which is locked in the fracture table boot.
- Remove the 2 guide pins
- Insert the Fixion nail (Carbofix Orthopedics, Herzeliya, Israel)

For the Fixation nail

- Initial training
- Select the correct nail length and diameter according to the medullary canal diameter based on preoperative templating. Nail diameter should be smaller than the medullary isthmus by approximately 2 mm.
- No reaming is necessary before insertion
- Fill the pump with sterile saline. Verify there are no air bubbles within the pump.
- Insertion point of the nail at the greater trochanter should be carefully evaluated regarding required varus-valgus correction.
- Before inflating the nail, assess correct derotation and proceed to inflate the nail
- When performing inflation of the nail, assess contact of the nail to the medullary canal using fluoroscopy. The nail should never be inflated beyond 70 bars (propagation of the osteotome to a fracture may occur if the nail exceeds this pressure).
- Inflation should be performed “step by step.” Stop inflating if any resistance is felt.
- Protective weight bearing should be indicated for 4 to 6 weeks postoperatively to prevent bending of the nail in obese or hyperactive patients
- This nail should never be used in patients with fragile bones (severe osteoporosis or osteogenesis imperfecta). In this population, inflation of the nail may produce a fracture.

swelling.²⁴ These symptoms not infrequently necessitate a second surgery to remove the screws. These complications are not observed with the Fixion nail because locking screws are not necessary. In addition, the Fixion nail uses its longitudinal expanded bars along the endosteal wall of the femur to enable immediate rotational stability. Weight-bearing forces are homogeneously shared on the entire diaphysis, unlike with classical interlock-

ing nails, which use 3-point fixation. Once bony healing has occurred, the nail can be deflated and removed if deemed necessary.

As with any novel device or technology, surgeons must become familiar with this intramedullary saw and nail and their indications for use prior to employing either in an operative setting. Reported complications using the Fixion nail have been mainly related to lack of experience

(eg, failing to expand the nail or breaking its inserter). In 1 case, the nail deflated 2 weeks after insertion, which resulted in nonunion. The authors believe that the latter complication can be avoided by expanding the system progressively. When surgeons feel resistance in the screw mechanism of the pump, they should avoid inflating it further and wait for the pressure to fall below 50 bars before proceeding.²⁴

Before using the intramedullary saw, both the size of the medullary canal and the thickness of the femoral cortex should be determined with anteroposterior and lateral views of the femur. If thick cortices are observed, intramedullary reaming should be considered to allow insertion of a saw of adequate size. If reaming is performed, careful evaluation of the anterior cortex with an image intensifier should be performed to avoid exces-

sive thinning that could lead to comminution of the osteotomy. Some surgeons may also experience difficulty with initial saw insertion. This can be prevented by gently working the saw into position, turning it back and forth with an oscillating motion as it is advanced. Breakage at the bushing connection of the saw has also been reported. Advancing the saw down the canal should be tight, but excessive force should not be required. Broken saws and/or connections may require open exposure to remove the hardware.²⁵ Technical pearls and tips for successful employment of this technique are outlined in **Table 2**.

CONCLUSION

Femoral derotational osteotomy with an intramedullary saw and fixation with an expanding nail is an effective, minimally invasive surgical technique. This technique allows reduced surgical time and fluoroscopy exposure and the theoretical advantage of faster bony healing with preservation of the local tissues and blood supply at the osteotomy site. As with any new technique, to achieve confidence and skill with these instruments, surgeons must be trained, preferably in a ca-

daver laboratory setting, prior to surgery.

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