The “Inside-Out” Technique for Correcting a Fixed Varus Deformity with Flexion Contracture in Total Knee Arthroplasty

Chitranjan S. Ranawat, MD, Morteza Meftah, MD, and Amar S. Ranawat, MD

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Introduction

The inside-out technique is a safe and reproducible method to effectively correct a fixed varus-flexion deformity during total knee arthroplasty by performing a posteromedial capsular release and so-called pie-crust lengthening of the superficial medial collateral ligament (sMCL).

The traditional method of correcting a fixed varus-flexion deformity in total knee arthroplasty requires detachment of the posteromedial aspect of the capsule and the sMCL from the tibia, and partial or complete release of the semimembranosus tendon and/or pes anserine insertion¹. This traditional method can cause overrelease of the sMCL, hematoma formation, knee joint line elevation, and instability, and it can increase the need for constrained implants²⁻⁵.

The inside-out technique involves performing a capsulotomy of the posteromedial aspect of the capsule at the level of the tibial cut and performing a controlled lengthening of the sMCL by pie-crusting it and serial manipulations. This method minimizes the aforementioned risks of overrelease of the sMCL.

The technique is performed in six steps:

Step 1: Preoperative planning

Step 2: Exposure

Step 3: Tibial and femoral cuts

Step 4: Posteromedial capsulotomy

Step 5: Pie-crusting of the sMCL

Step 6: Flexion gap balancing

Step 1: Preoperative Planning (Fig. 1)

Analyze preoperative radiographs as a key step in planning the surgery for the required amount of osseous cuts and soft-tissue release.

- Measure the amount of varus-flexion deformity on anteroposterior and lateral knee radiographs. Confirm the radiographic degree of the deformity with physical examination.
- Note any elongation on the lateral side (Fig. 1, yellow arrowhead) and measure the amount of the deformity that is correctable with valgus stress on physical examination.

Step 2: Exposure (Fig. 2)

Obtain adequate exposure for proper visualization and assessment.

- Without using a tourniquet, expose the knee in flexion with a medial parapatellar approach and a medial periosteal elevation proximal to the pes anserine insertion. (The use of a tourniquet during exposure is possible with this technique; however, we do not use one during exposure as knee flexion substantially reduces bleeding.) Release both cruciate ligaments (this technique is designed for a posterior stabilized knee system) and evert the patella.
- Subluxate the tibia anterior to the femur using the Ran-sall maneuver⁶ by hyperflexion and external rotation of the tibia to expose the entire articular surface of the tibia.

Step 3: Tibial and Femoral Cuts

Adequate bone cuts with proper alignment are an essential step of this technique.

- Cut the proximal part of the tibia at 90° to the long axis of the tibia so that the cut surface is parallel to the tibial plafond. Appropriate slope for a posterior stabilized system should be incorporated into the cut.

- Cut 8 to 10 mm of bone off of the uninvolved lateral tibial plateau. Cut a lesser amount if there is any elongation on the lateral side based on the anteroposterior radiograph. Remove all osteophytes and perform a reduction osteotomy to decompress the medial soft-tissue sleeve. Confirm tibial alignment (Fig. 3).
- Remove 8 to 10 mm of the distal part of the femur with a valgus cut of 5° to 7° based on the mechanical axis of the femur.

Step 4: Posteromedial Capsulotomy

This is the most important step for extension balancing in knees with flexion contracture; the posteromedial aspect of the capsule in varus deformity should be safely incised at the level of the tibial cut.

- Inflate the tourniquet. Bring the knee to full extension. Place a 20-mm spacer block into the extension gap and check stability. The gap should be asymmetric and trapezoidal. If the spacer block can be placed in the lateral side, the bone cuts are adequate (Fig. 4). If the spacer block cannot fit into the lateral side, then additional bone resection is required. There should be a “springy give” of 2 to 3 mm in the lateral side when a varus force is applied. The medial side will be tight and requires release.
- Remove the spacer and place a lamina spreader to tension the extension gap. Irrigate and dry the posterior aspect of the capsule. Remove any remnants of the posterior cruciate ligament (PCL) and menisci. Release the tight posteromedial aspect of the capsule with electrocautery at the level of the tibial cut from the insertion of the PCL to the posterior margin of the sMCL (Fig. 5). Use a periosteal elevator to evaluate the completeness of the release (Fig. 6).
- Check the extension gap again with varus/valgus stress tests using a spacer block. If the extension gap is still trapezoidal and tight medially, proceed with pie-crusting of the sMCL.

Step 5: Pie-Crusting of the sMCL

Perform pie-crusting followed by serial manipulations in a controlled manner to avoid overrelease of the sMCL.

- With a lamina spreader in the extension gap, palpate the tight fibers of the sMCL at the joint level. To pie-crust the sMCL, use a number-11 scalpel blade and stab the tight bands in an

oblique manner three, four, or five times (Fig. 7). Place the spacer block back and manipulate the knee with a repeated valgus stress. Repeat pie-crusting and serial manipulations until a rectangular extension gap is achieved.

- A balanced extension gap allows for 2 to 3 mm of “springy give” with the spacer block in place on both the medial and the lateral side when you apply a valgus and varus force, respectively (Fig. 8).

Step 6: Flexion Gap Balancing

This is a key step for proper balancing, femoral sizing, rotation, lateralization, and patellofemoral tracking.

- Balance the flexion gap using the “parallel to the tibial cut technique.”^{7,8}
- Bring the knee to 90° of flexion. Size the femur appropriately using either an anterior or posterior referencing system to restore the posterior offset and avoid so-called notching of the anterior cortex. Place the femoral cutting block and use a lamina spreader in the middle of the block (Fig. 9).
- While an assistant is manually unloading the medial side of the knee, measure the medial and lateral sides of the flexion gap. The size of the flexion gap should be equivalent to, or 2 mm less than, the size of the extension gap.
- Rotate the cutting block until the medial and lateral flexion gaps are equal and symmetric (Fig. 10). Use a spacer block to assess flexion stability. Make the chamber and box cuts. Lateralize the femoral component to match the lateral edge to the lateral condyle to reduce the Q angle. Place the trial components and test the stability of the knee through a full range of motion.

Results

From October 2006 to December 2009, thirty-one consecutive patients (thirty-four knees) with a severe fixed varus-flexion deformity (varus alignment of $\geq 15^\circ$ and flexion contracture of $\geq 5^\circ$) underwent total knee arthroplasty with the inside-out technique (Video 1)⁹. The mean duration of follow-up was 3.1 ± 1.1 years (range, 1.7 to 4.9 years). The mean age of the patients was 69.9 ± 9.1 years (range, 51.1 to 93.5 years). All patients received a Press Fit Condylar (P.F.C.) Sigma posterior stabilized (PS) implant (DePuy Johnson & Johnson, Warsaw, Indiana): twenty-nine knees (twenty-six patients) had a fixed-bearing design, two knees (two patients) had a rotating-

platform mobile-bearing design, two knees (two patients) had a constrained rotating-platform design, and one knee (one patient) had a rotating-platform high-flexion design.

There were no cases of bearing spinout, hematoma formation, overrelease of the sMCL, or acute or delayed instability. The mean Knee Society pain score and Knee Society function score improved from 39.5 ± 12.6 and 47.1 ± 17.8 preoperatively to 93.2 ± 10.5 and 78.5 ± 21.9 at the time of final follow-up, respectively. All patients were able to participate in activities of daily living such as personal care, putting shoes or socks on, and driving an automobile without any real difficulty. Sixty-five percent (twenty) of the patients could kneel, 71% (twenty-two) could squat, and 29% (nine) could sit on their heels without any major difficulty. Thirty-two percent (ten) participated in more than one recreational activity, such as walking >1 mile (>1.6 km) per day, gym workout, swimming, tennis, or golf, at the time of final follow-up. The mean satisfaction score was 8.6 ± 2.2 (range, 0 to 10).

Anteroposterior and lateral weight-bearing radiographs at the time of follow-up showed no change in the position of the components with satisfactory alignment and cement mantle (Fig. 11). The mean preoperative femorotibial alignment was $21.1^\circ \pm 4^\circ$ (range, 15° to 30°) of varus, which was corrected to $4.5^\circ \pm 1.6^\circ$ (range, 2° to 8°) of valgus. The mean preoperative flexion contracture was $10^\circ \pm 3.5^\circ$ (range, 5° to 20°). Only two patients (three knees) had residual flexion contracture (all $\leq 5^\circ$) postoperatively. The mean range of motion improved from $103.3^\circ \pm 14.1^\circ$ (range, 75° to 120°) preoperatively to $119.1^\circ \pm 8^\circ$ (range, 100° to 135°) at the time of final follow-up. Four knees had radiolucency at tibial zone 1 due to medial tibial plateau bone loss. There was no evidence of loosening or osteolysis. The joint line and the posterior offset were restored within 1 ± 1.2 mm and 0.6 ± 1.6 mm, respectively, compared with the preoperative measurements. There was no overstuffing of the patella. The mean patellar thickness was reduced from 32.3 ± 5.7 mm preoperatively to 30.1 ± 4.6 mm after surgery. Preoperative patellar displacement was 1.8 ± 2.1 mm laterally, which was corrected to 0.5 ± 0.8 mm postoperatively. The mean postoperative patellar tilt was $2.6^\circ \pm 2.9^\circ$. The mean postoperative Insall-Salvati ratio¹⁰ was 1.015 ± 1.1 ; range, 0.73 to 1.38, which did not change from the preoperative measurement (1.017 ± 1.1 ; range, 0.78 to 1.34).

What to Watch For

Indications

- The inside-out technique is indicated during total knee arthroplasty for any fixed varus-flexion deformity of the knee of $>10^\circ$.

Contraindications

- Correctable varus-flexion deformities of the knee do not require this technique.

Pitfalls & Challenges

- Cut less bone when there is elongation of the lateral structures as evidenced by the preoperative standing anteroposterior radiograph or else the extension gap may become too large.
- Perform the posteromedial capsular release using electrocautery at the level of the tibial cut from the insertion of the PCL to the posterior border of the sMCL. Be aware of the neurovascular structures in the posterior aspect of the knee when performing this release.
- Pie-crust the tight bands of the sMCL with three, four, or five oblique stabs using a number-11 scalpel blade. Be careful to avoid transecting the sMCL completely during the controlled lengthening process.
- Serial manipulations, complete capsular release, and repeat pie-crusting may be required before a balanced extension gap is achieved.
- Balance the flexion gap using the “parallel to the tibial cut technique.” Restore femoral posterior offset, avoid notching, and lateralize the femoral component.

Clinical Comments

- How do you avoid overreleasing the sMCL?
- What are the advantages of balancing the extension gap prior to the flexion gap?
- What steps should you take to ensure an accurate tibial cut 90° to the mechanical axis?
- How do you avoid cutting more than enough tibia when the lateral structures are elongated?
- What are the advantages of using the “parallel to the tibial cut technique” compared with using the Whiteside line or the transepicondylar axis for femoral rotation?

Chitranjan S. Ranawat, MD
Morteza Meftah, MD
Amar S. Ranawat, MD
Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021. E-mail address for M. Meftah: Mef-tahM@HSS.edu

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Figures

Fig. 1

Preoperative anteroposterior radiograph of a patient with a fixed varus-flexion deformity. The amount of varus is measured by the femorotibial anatomical axis (red lines), which is 15° in this case. Note the lateral soft-tissue elongation (yellow arrowhead).

Fig. 2

Adequate exposure and subluxation of the tibia. The tibia is mobilized anterior to the femur with hyperflexion and external rotation to fully visualize the articular surface of the tibia.

Fig. 3

Checking the tibial cut with use of an alignment rod. The distal aspect of the rod should be in the middle of the tibial plafond distally to ensure a 90° proximal tibial cut.

Fig. 4

Checking bone cuts for the extension gap. If a 20-mm spacer block can be placed in the lateral gap, the bone cuts are adequate. Extension gap balance should be achieved with soft-tissue release by using the inside-out technique.

Fig. 5

Posteromedial capsular release with use of electrocautery. Place a lamina spreader and release the tight posteromedial aspect of the capsule at the level of the tibial cut from the insertion of the PCL to the posterior border of the sMCL.

Fig. 6

Assessing the posteromedial capsulotomy. Palpate with a periosteal elevator to assess for completeness of the release.

Fig. 7

Pie-crusting of the sMCL. If, after the posteromedial capsular release, the extension gap is not yet balanced, proceed with pie-crusting of the sMCL. Feel the tight fibers of the sMCL and use a number-11 scalpel blade to pie-crust these fibers (arrowhead) at the joint level with three, four, or five oblique stabs.

Fig. 8

Serial knee manipulations with repeated valgus stress will further elongate the sMCL. A balanced extension gap is achieved when 2 to 3 mm of “springy give” is apparent on both sides of the spacer block when a valgus and varus force is applied (arrow).

Fig. 9

Assessment of the flexion gap. Place the proper-size femoral cutting block to restore the posterior offset without anterior notching. Use a spreader in the middle of the block and measure the medial and lateral gap while an assistant is manually unloading the medial side of the knee. Note the trapezoidal space (black lines).

Fig. 10

Balancing the flexion gap with use of the “parallel to the tibial cut technique.” To correct the trapezoidal space to a rectangular space, adjust the cutting block by rotating it so that it is parallel to the tibial cut surface (black lines).

Fig. 11

Postoperative anteroposterior radiograph of the patient shown in Fig. 1 ten years after correction of a fixed varus-flexion deformity with use of the inside-out technique.

Fig. 1

Fig. 2

Fig. 3

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Fig. 11