Case Report

Antegrade Femur Lengthening with the PRECICE Limb Lengthening Technology

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ABSTRACT
This is a case illustrating a 4.5 cm femur lengthening for congenital LLD. The PRECICE internal lengthening nail was used and the recovery was fast with normal unassisted walking at 4 months.

PATIENT HISTORY
The patient is a 25 year old male with congenital LLD of 4.5 cm and without deformity. No previous treatment was rendered. The patient and the family were not interested in limb lengthening using external fixation at earlier points in his life.

PREOPERATIVE CLINICAL PHOTOS AND RADIOGRAPHS

Figure 1: (A,B) Front and back view showing left lower extremity shortening of 4.5 cm.

Figure 2: Preoperative x-rays
(A) Standing x-ray shows LLD of 4.4 cm. MAD is normal. (B) AP femur showing small IM canal. (C) Lateral femur showing normal anterior bow with apex 15 cm distal to tip of trochanter. (D) Merchant view of knees showing normal patella alignment.
thick part of the nail is pulled out of the distal segment.

In this case, a 305 mm nail was used. Subtract the starting length of the small diameter telescoping part of the nail (30 mm), the planned lengthening (45 mm), and the minimum length of the thickest part in the distal segment (50 mm).

\[305 - (30 + 45 + 50) = 130\text{ mm}\]

The osteotomy must be less than 180 mm from the proximal end of the bone. In this case, 150 mm was chosen without a problem.

- Reaming 1.5 to 2 mm over the diameter of the nail should be done. In this case, the bone was reamed to 12.5 mm to accommodate a 10.7 mm nail.
- Although lengthening should ideally be done along the mechanical axis of the femur when using an IM nail, lengthening is along the anatomical axis. Theoretically, this could increase valgus alignment.

In a normally aligned limb, intramedullary lengthening along the anatomical axis of the femur results in a lateral shift of the mechanical axis by approximately 1 mm for each 1 cm of lengthening. In practical terms, this is not a substantial problem. Compare figures 2A to 5A and you will notice no increase in valgus. During lengthening, mild varus of the bone offsets the medialization of the distal femur.

TREATMENT STRATEGY

- Femoral lengthening using an intramedullary limb lengthening nail
- Antegrade approach
- Osteotomy at the apex of the femur anterior bow on the lateral x-ray
- Iliotibial band (ITB) tenotomy

BASIC PRINCIPLES

- Osteotomy to be completed at the apex of the anterior bow to allow for a longer, straight nail to be inserted.
- Piriformis or trochanteric entry can be used based on surgeon preference.
- Nail length choice and osteotomy location requires planning. The goal is to have at least 5 cm of thick part of the nail in the distal segment at the end of distraction for optimal stability. During distraction, the

![Figure 3A](image1)
![Figure 3B](image2)
![Figure 3C](image3)
![Figure 3D](image4)
![Figure 3E](image5)

Figure 3: Intraoperative C-arm x-ray images (A) Multiple drill holes are made at intended site of osteotomy. (B) Proximal rotational pin is placed posterior to intended path of the nail. A second rotational pin marker is inserted into the distal femur beyond the anticipated end of the nail. Guide wire is inserted into center of trochanter. (C) Cannulated reamer opens path into IM canal. Note the proximal rotation marker. (D) After reaming with flexible reamers 1.5–2 mm over the diameter if the IM nail, the solid nail is inserted without guide wire up to the osteotomy site. The osteotomy is then completed with an osteotome. (E) The IM nail is then passed across the osteotomy. (F) The proximal and distal rotational marker pins are used to assure optimal rotational alignment. (G) The external magnet controller (EMC) is applied over the magnet in the nail. The skin is marked so that the EMC can be reliably placed for distraction. (H) One week after distraction started showing distraction gap of 7 mm. Note the cloud of new bone already seen.

![Figure 3F](image6)
![Figure 3G](image7)
![Figure 3H](image8)

![Figure 3A](image9)
![Figure 3B](image10)
![Figure 3C](image11)
![Figure 3D](image12)

![Figure 3E](image13)

![Figure 3A](image14)
![Figure 3B](image15)
![Figure 3C](image16)

![Figure 3D](image17)

IMAGES DURING TREATMENT

- In a normally aligned limb, intramedullary lengthening along the anatomical axis of the femur results in a lateral shift of the mechanical axis by approximately 1 mm for each 1 cm of lengthening. In practical terms, this is not a substantial problem. Compare figures 2A to 5A and you will notice no increase in valgus. During lengthening, mild varus of the bone offsets the medialization of the distal femur.

![Figure 4A](image18)

Figure 4: (A) Picture of the PRECICE Nail. (B) Anatomy of the PRECICE nail on x-ray. (C) Placement of the EMC on the thigh over the magnet in the nail for distraction (see Figure 3G).
TECHNICAL PEARLS

1. Use rotation markers to prevent rotational deformity. Place rotational pins parallel to each other.
2. Correct preoperative rotational deformity (not present in this case) by placing the rotational pins with the amount of angular deformity to be corrected. Use an intra-operative goniometer. After the osteotomy, correct the rotation and make the pins parallel.
3. Varus or valgus deformity (not in this case) can be corrected by performing the osteotomy at the apex of deformity to acutely correct the deformity and then insert nail.
4. Rotate osteotomy around the IM nail before insertion of locking screws to assure a complete osteotomy.
5. Dr. Rozbruch prefers to insert the distal interlocking screws to prevent malrotation. The leg and rod are rotated to get “perfect circles” needed for freehand distal locking screw insertion. Then the leg is carefully positioned using the rotational pins as guides and the proximal interlocking screws are easily inserted using the jig.

OUTCOME CLINICAL PHOTOS AND RADIOGRAPHS

Figure 5: (A) Bipedal standing x-ray at end of distraction (50 days after surgery) showing equal leg lengths. Note MAD position relative to preoperative (Figure 2A). Increase in valgus did not occur. (B,C) AP and lateral x-ray of femur 4 months after surgery showing excellent bone healing progression of 4.5 cm regenerate. Note straightening of the anterior bow of the femur. Note mild varus due to proximal propagation of osteotomy on medial cortex. Full weight bearing was allowed.

AVOIDING AND MANAGING PROBLEMS

1. Avoid propagation of the osteotomy to optimize the angular control of the nail. In this case the small proximal medial propagation of the osteotomy led to mild varus.
2. If the canal diameter is greater than the IM nail at the osteotomy site, blocking screws should be inserted to prevent deformity. They work by narrowing the IM canal. Blocking screws are to be inserted in the concavity of the anticipated deformity.
3. Mark the location of the magnet in the nail on the skin. The external magnet controller must be placed directly over the magnet within the nail to actuate a distraction.
4. Pre-drill the osteotomy before reaming. This decreases pressure in the IM canal during reaming and protects against fat embolism syndrome.
5. The ITB tenotomy helps prevent knee contracture during distraction.

Figure 6: Clinical photos 4 months after surgery (A) Front view showing equal leg lengths and no deformity. (B) Side view showing full knee extension. (C) Knee flexion to 130 degrees. Note the percutaneous insertion of distal locking screws (yellow arrow) and the incision for routine release of the iliotibial band (black arrow).

Figure 7: (A,B) AP and lateral x-rays 7 months after surgery.

Figure 8: (A,B) AP and Lateral x-rays 10 months after initial surgery and one week following nail removal.
References and Suggested Reading

