Adult Femur Lengthening Algorithm
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S. Robert Rozbruch, MD
Chief, Limb Lengthening & Complex Reconstruction Service
Professor of Clinical Orthopedic Surgery
Disclosures

Small Bone Innovations: consultant and royalties
Smith and Nephew: consultant
Treatment options

- External Fixation
- Integrated Fixation
  - LON
  - LATN
  - LAP
- Internal lengthening nail
  - Piriformis
  - Trochanteric entry
  - retrograde
External Fixation

- Historical

- Indications
  - When other techniques are contraindicated

- Pros
  - Quick surgery
  - Minimally invasive
  - Little blood loss
  - versatile

- Cons
  - Pin site problems
  - Long EFI
Normal tibia and Varus femur

Step 1

Step 2a

Step 2b

LPFA = 90°

Step 3

4-25

Mag = 22°

MPTA = 87°

CORA

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Normal tibia, valgus femur

- MAD 36 mm lateral
- LLD 4 cm
- 13 deg CORA
- 13 deg VALGUS
- 87
 Desired lateral translation
Integrated Fixation

- Lengthening over nail (LON)
- Lengthening and then plating (LAP)
- Lengthening and then Nailing (LATN)

**Pros**
- Decreased time in external fixation

**Cons**
- 2 surgeries
- Still wear ex fix
Femoral Lengthening with Lengthening over a Nail has Fewer Complications than Intramedullary Skeletal Kinetic Distraction

Shahab Mahboubian DO, MPH, Matthew Seah MBChB, Austin T. Fragomen MD, S. Robert Rozbruch MD
10 cm lengthening
Lengthening of the Femur Over an Existing Intramedullary Nail

Han Jo Kim, MD,* Austin T. Fragomen,* Keith Reinhardt, MD,* James J. Hutson, Jr, MD,† and S. Robert Rozbruch, MD‡

Summary: Leg length discrepancies can occur despite successful union of femur fractures after intramedullary nailing (IMN). Often, the leg length discrepancy can result in significant disability to the patient, altered gait biomechanics, pelvic obliquity, and pain. Therefore, a successful clinical result for such deformities after IMN involves addressing the leg length inequality. Femoral reconstruction with an osteotomy around an existing intramedullary nail was introduced to address axial deformity correction and limb lengthening without changing or removing a previously inserted IMN. This technique uses the principles of lengthening over an IMN. The presence of the nail has minimized the time needed for the external fixator because the nail supports the regenerate bone or osteotomy during the consolidation phase. With this technique, surgery is minimized by avoiding the need for exchange nailing.

Key Words: posttraumatic deformity, Ilizarov, femur, osteotomy, intramedullary nail

(J Orthop Trauma 2011;25:681–684)

When angular deformities result, the mechanical axis can be significantly affected, leading to asymmetric joint loads across the hip, knee, and ankle as well as alterations in the lever arms of muscle (ie, extension/flexion deformities). This can lead to quadriiceps weakness as well as increased energy expenditure for gait.¹ Axial deformities that result in a significant leg length discrepancy and/or rotational deformities can also be problematic for the patient and may lead to hip, knee, and low back pain; awkward gait; and extensor mechanism weakness if left untreated.²,³,⁵

Correcting these malunions can be challenging, and often reoperation can lead to significant morbidity for the patients. The abductors can become more scarred and weakened and sometimes the deformity can persist despite efforts for correction. This has led to a novel technique in which bony deformity can be corrected without nail removal obviating the need to surgically violate the hip abductors in antegrade nailing. In the case of retrograde nails, there is no need to perform an arthrotomy, split the patella tendon, or evert the patella.⁷
Lengthening Over an Existing IMN

LLD 3 cm
CUT BONE AROUND EXISTING IM NAIL
LLD 7 cm, old osteomyelitis

Free fibula distally
Pins placed out of nail path
Poor control of alignment
Acute correction needed at nail insertion

LON would not have worked
Does Lengthening and Then Plating (LAP) Shorten Duration of External Fixation?

Ryhor Harbacheuski MD, Austin T. Fragomen MD, S. Robert Rozbruch MD

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Abstract

Background  Classic bone lengthening requires patients wear external fixation for the distraction and consolidation phases and there is fracture risk after frame removal. Our technique of lengthening with the Taylor Spatial Frame™ and then insertion of a locked plate allows earlier removal of the external fixator during consolidation. Plate insertion is accomplished through a clean pin-free zone avoiding contamination and before frame removal maintaining bone 27 extremities in each group. We compared time wearing the frame, bone healing index, external fixation index, joint ROM, alignment, and complications.

Results  The time wearing the frame and external fixation index were lower in the LAP group (4.5 versus 6.2 months and 1.5 versus 2 months/cm). Deviation from normal alignment was observed in seven and six patients in the LAP and classic group, respectively. Varus malalignment in two patients in the LAP group was associated with plate
Polio
LLD
Fexion deformity
Weak quads
Harvest BMAC

Intramedullary stimulation
Internal Lengthening Nail

**Requirements**
- Reliable mechanism for rate and rhythm
- **IM canal must be suitable**
  - Size
  - Geometry
- **Deformity**
  - Correct with nail
  - Correct with plate @ different level

**Pros**
- No ex fix
- No pin problems
  - Pin infections
  - Soft-tissue tethering
- Better joint ROM
- Very accurate

**Cons**
- Invasive
- Infection risk
- Blood loss
Motorized internal lengthening IM nail
Trochanteric Entry
Good for adolescent < 18 yrs.
LLD = 4.5 cm
25 y/o male
Congenital LLD
Troch entry Nail can lead To varus

3 months postop!
12 year old male with congenital LLD
Clubfoot, LLD 1 inch

Piriformis Entry- my preference
In adult
Malunion, LLD 3 cm
AP translation & PC deformity

Osteotomy, translate with Osteotome, pass wire, Ream
Blocking screws needed to narrow canal
5 cm LLD; varus, procurvatum
Precision of the Precice® Internal Lengthening Nails

Yatin Kirane, MBBS, D.Ortho, MS, PhD
Austin T. Fragomen, MD
S. Robert Rozbruch, MD

Limb Lengthening and Complex Reconstruction Service
Hospital for Special Surgery, New York, NY

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Accepted to CORR
Precice® Nail  Ellipse Technologies Inc., Irvine, CA

- Telescopic, magnet-operated device
- Recent FDA approval
- Clinical efficacy not established

Internal nail architecture

External remote control magnet in operation
Surgical Technique

Rotation marker pins

Vent hole & multiple drill hole osteotomy

Osteotomy completion before advancing the nail
Intraop Magnet Localization & Distraction

Localization of the internal magnet

Intraop distraction
Methods

- 17 femur and 8 tibia lengthening cases
- Medical records were reviewed for:
  - Patient characteristics
  - Etiology
  - Surgery details
  - Distraction process
  - Bone alignment
  - Adjacent joint range of motion (ROM)
  - Any complications
I. Accuracy of Lengthening
   ◦ Distraction distance & accuracy measured using a calibrated digital radiology system (PACS, OnePacs LLC, New York, NY)

\[
A) \quad \% \text{Error} = \frac{\text{Distraction prescribed} - \text{Lengthening measured}}{\text{Distraction prescribed}} \times 100
\]

\[
B) \quad \text{Accuracy of distraction} = 100 - \% \text{Error}
\]

II. Change in bone alignment

III. Effect on adjacent joint ROM
I. Accuracy of Lengthening

At 19 weeks follow-up (range, 1-42 weeks):

- Average lengthening was **33.65 mm** (range, 14mm-61mm)
- Accuracy was **99.3% ± 0.23%**
## II. Absolute Change in Bone Alignment

<table>
<thead>
<tr>
<th>BONE</th>
<th>ANGLE</th>
<th>ABSOLUTE CHANGE (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Femur</td>
<td>Lateral distal femoral angle (LDFA)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Procurvatum/Recurvatum</td>
<td>6</td>
</tr>
<tr>
<td>Tibia</td>
<td>Medial proximal tibial angle (MPTA)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Procurvatum/Recurvatum</td>
<td>3</td>
</tr>
</tbody>
</table>

- Intentional reduction of femur bow (5/17)
- Blocking screws (4/17 femur & 6/8 tibia)
III. Joint ROM

- Hip, knee and ankle ROM well maintained
- **Temporary** loss of motion in early postop period

<table>
<thead>
<tr>
<th>MOTION</th>
<th>ABSOLUTE LOSS (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Knee Flexion</td>
<td>13</td>
</tr>
<tr>
<td>Knee Extension</td>
<td>0</td>
</tr>
<tr>
<td>Ankle Dorsiflexion</td>
<td>3</td>
</tr>
<tr>
<td>Ankle Plantarflexion</td>
<td>6</td>
</tr>
</tbody>
</table>

- ITB release (10/17 femur)
- Gastrocnemius recession (5/8 tibia)
Example: Retrograde Femur

- 30M
- 3.6 cm LLD
- 7° genu valgum (MAD 14 mm lateral)
- 10° ER deformity
- Post-traumatic growth arrest after R femur Fx
- Lower back and R LL pain
Example: Retrograde Femur

- Blocking screws
- To narrow canal
- Placed in concavity of anticipated deformity

24 weeks after surgery
Treatment options

- External Fixation
- Integrated Fixation
  - LON
  - LATN
  - LAP
- Internal lengthening nail
  - Piriformis
  - Trochanteric entry
  - retrograde