Simultaneous Lengthening and Deformity Correction over Customized Intramedullary Locking Nail (LON) for Multidimensional Deformity of the Proximal Tibia

P. H. Thaller* and F. Wolf
3D-Surgery, Department of General, Trauma, Hand and Plastic Surgery, Ludwig-Maximilians-University (LMU), Campus Innenstadt, Munich, Germany

Abstract

Deformity correction using intramedullary (IM) nailing is a well-established technique. Integrated techniques like lengthening over nail (LON), lengthening and then nailing (LATN), lengthening and then plating (LAP), and lengthening along a plate (LAAP) can substantially reduce external fixation time.

This is the case of a 17 year old patient with biplanar malalignment of the proximal tibia with minor rotational deformity and shortening. All aspects of the deformity could be addressed using a LON technique with a distraction index (DI) of 1 mm/d, an external fixation index of (EFI) 21 d/cm, and a weight bearing index (WBI) of 34 d/cm. The final result was excellent with fast recovery and early return to sports. The latest follow-up after 2.5 years confirmed full recovery.

1 Brief Clinical History

The 17 year old patient presented with a leg length discrepancy of minus 20 mm of the right leg and disabling instability of the right knee joint. He reported the cause to be from a hard hit by an ice hockey puck at the proximal tibia when he was younger. The clinical examination of the right knee showed apparent hyperextension with a range of motion of E/F 20-0-140 and a clinically evident patella baja. In 0° extension position, the knee joint had severe medial-lateral instability. In addition there was a valgus malalignment and there was a slight torsional deviation of 10° less external torsion compared to the left lower leg.

The patient underwent acute correction of the deformity, insertion of an IM nail, and LON with a circular external fixator. Removal of circular frame and distal interlocking were performed after 40 days. Partial weight bearing was administered for 10 weeks after initial surgical procedure, and within this time the patient reached full, symmetric range of motion of both knees. A distraction index (DI) of 1 mm/d was reached and treatment could be finished with an external fixation index (EFI) of 20 d/cm and a weight bearing index (WBI) of 35 d/cm. At a late follow-up examination after 2.5 years, the patient did not report about any complaints or physical limitations.

2 Preoperative Clinical Photos and Radiographs

See Figs. 1, 2, and 3.

*Email: peter.thaller@med.uni-muenchen.de
3 Preoperative Problem List

Combined biplanar and torsional deformity of the proximal tibia with:

(a) Pathologic posterior proximal tibial angle (PPTA) of 106° representing apex posterior deformity of the proximal tibia
(b) Malalignment with mechanical axis deviation (MAD) of 16 mm lateral to midline
(c) Leg length discrepancy (LLD) of minus 20 mm
(d) Slight torsional deformity with 10° less external torsion of the right lower leg
(e) Patella baja with subsequent limited nailing approach to the proximal tibia
(f) Disabling knee joint instability in neutral position

4 Treatment Strategy

Lengthening over a conventional intramedullary nail with multiple proximal interlocking options was combined with acute deformity correction and fixation by circular Ilizarov frame for the distraction period. For the correction of the PPTA, preparation of the medullary cavity of the proximal fragment was done with a special steel sleeve system and rigid reamers. Because of a lack of sufficient experience with the new suprapatellar approach at that time, the surgery was planned and performed with an infrapatellar approach. The titanium alloy intramedullary nail was customized in its curvature in both planes by a sterile custom-made bending device.
In contrast to HEF, the LON technique does not allow later correction of the alignment, and a preoperative “endpoint first” (EPF) planning was performed, which defines the precise osteotomy position and the shape of the intramedullary cavity’s preparation.

Steps of the surgical procedure:

1. Preparation of the medullary cavity (path of the nail) in the proximal fragment
2. Minimally invasive drill bit osteotomy, minimal-open osteotomy of the fibula
3. Preparation of the medullary cavity of the distal fragment
4. Osteosynthesis with intramedullary nail and intraoperative control of axis by x-ray grid method and control of range of motion
5. Removal and customizing of the nail for final axial corrections
6. Reinsertion of the nail with proximal interlocking and mounting of an Ilizarov circular frame, considering the desired torsional correction

**Fig. 2** (a) Digital analysis (CorelDraw®) of the long-standing radiograph (LSR). Mechanical and anatomic axes are marked and the projection of the patellae is outlined. The valgus deformity of the right leg shows a mechanical axis deviation of 16 mm lateral to midline indicating valgus. In total the length discrepancy with predominant shortening of the right lower leg is 20 mm. (b) On the lateral view the posterior proximal tibial angle (PPTA) is 106° (normal is 75–85°)
7. Distal interlocking and removal of the Ilizarov frame in a second minor surgical procedure after reaching the distraction goal (confirmed by low-dose CT scout)

5 Basic Principles

This case requires meticulous preoperative clinical and radiological analysis of the deformity (Thaller et al. 2005). Clinical findings and radiological analysis of alignment and angles show a deformity of the proximal tibia, which results in valgus axis and recurvatum deformity of the proximal tibia. It is important to understand that the hyperextension of the knee on physical exam was apparent and that the etiology is an apex posterior (recurvatum) deformity of the proximal tibia. A growth plate injury of the anterior aspect of the proximal tibial growth plate resulted in asymmetrical growth and the apex posterior deformity.
6 Images During Treatment

See Figs. 4, 5, 6, 7, and 8.

7 Technical Pearls

- Digital preoperative planning of multiplanar deformity correction by applying the EPF method.
- Lengthening over nail (LON) technique.
- Stable fixation of the short proximal fragment by five proximal interlocking bolts and angular stable locking system (ASLS).
- Precise deformity correction with customized (bent) nail with:
  - Intraoperative control of alignment by x-ray grid method.
  - Sleeve system and rigid reamers for preparation of the medullar cavity.
  - Minimally invasive approaches and drill bit osteotomy of the tibia.
  - Short external fixation time.
  - Intraoperative use of external fixation to assist with the deformity correction (fixator-assisted nailing) and/or blocking screws can also be helpful in this case (editor’s comment, SRR).
Fig. 5  (a) Drill bit osteotomy of the tibia via stab incision and completion with an osteotome.  (b) The osteotomy of the fibula is done via minimal-open approach.
Fig. 6 Minimal incision approach. (a) Access to the medullary cavity via transverse approach (#), incision for osteotomy of the tibia with drill bit technique (†), stab incisions for proximal interlocking of the nail (*), (b) incision for fibular osteotomy (‡)

Fig. 7 (a, b) Intraoperative control of the required amount of correction by comparison of the preoperative planning with the intraoperative x-ray
8 Outcome Clinical Photos and Radiographs

See Figs. 9 and 10.

9 Avoiding and Managing Problems

Lengthening over a nail has several advantages in comparison to only external fixation by circular frame. The main advantage is mechanical stability and shorter external fixation time. Disadvantage is the lack of possibilities for further axial correction during the lengthening procedure. Therefore simultaneous lengthening over a nail and deformity correction requires meticulous preoperative planning according to the principles of deformity correction with intramedullary fixation. Preoperative long-standing radiographs are essential (Thaller et al. 2005). Meticulous planning by “endpoint first method” EPF and precise intraoperative controlled transfer, e.g., by applying the x-ray grid method, can provide proper alignment.

With all high tibial osteotomies, dorsal tilting of the tibial head is a common problem. A locking nail with polyaxial locking options and/or a blocking screw can help provide the necessary stability.

Drill bit osteotomy is a technique with a certain learning curve, and the risk of neurovascular damage should not be underestimated.
Fig. 9 (a) Three months after the beginning of the treatment (hair on the right lower leg has not yet grown again), stable standing on the right leg is possible. (b) Symmetric leg axis and length. (c) Full range of motion of the right knee.
Fig. 10 (a) LSR 3 months after operation; symmetric leg axis is shown. Note the fast consolidation of the bone regenerate. (b) Implant removal was performed 1 year after the first surgical procedure. This late follow-up of LSR after 2.5 years shows very good bone remodeling. (c) Excellent bone remodeling also on the side view.
10 Cross-References

- Acute Correction of Tibial Deformity & Plate Fixation, With Subsequent Lengthening Over Plate
- Complex Tibial Deformity: Acute Correction & IM Nail Fixation
- Plating After Lengthening
- Proximal Tibial Growth Arrest with Varus, Recurvatum, and Shortening After ACL Reconstruction. Correction with TSF
- Tibia Lengthening with Precise Internal Lengthening Nail

References and Suggested Readings


