45 Tibial and Femoral Osteotomy

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INTRODUCTION

Osteotomy is a reconstructive surgery that involves cutting the bone to attain limb deformity correction and/or limb length equalization. In this chapter, we focus on the long bones of the lower extremity: the femur and tibia. Osteotomy of the femur and tibia may be indicated for both children and adults. In most cases, the goal of rehabilitation is simply to maintain adjacent joint range of motion (ROM) and muscle strengthening as well as progressing gait within certain weight-bearing limitations. There are a variety of treatment variations that include location of osteotomy, acute or gradual deformity correction, bone lengthening, and choice of hardware. The etiologies of deformity include congenital, posttraumatic, and developmental. The etiology, location of the osteotomy, use of internal or external fixation, postoperative immobilization, and the amount of limb lengthening or shortening will affect the rehabilitation needs and challenges (Table 45.1).

SURGICAL PROCEDURE

Osteotomy is indicated for correction of deformity and/or limb lengthening. When analyzing a deformity, the proximal and distal bone axes are drawn to form an angle at the apex of deformity. In most cases, the osteotomy is performed at the apex of deformity; the bone is straightened and then stabilized. Deformity correction may be done acutely with an open, closed, or neutral wedge, and stabilized with plate and screws, an intramedullary (IM) rod, or an external fixator. The indications for gradual correction are large deformity, compromised soft-tissue envelope, and the need for bone lengthening. These are done with external fixation or an internal lengthening IM rod.

Distraction osteogenesis is used for gradual bone lengthening and deformity correction. Ilizarov showed that bone could successfully regenerate if a low-energy osteotomy was performed, proper stability was accomplished, and distraction was done with a proper rate and rhythm (usually 1 mm per day divided into 3–4 adjustments per day).

Osteotomy Technique Variations

Acute Deformity Correction and Insertion of Plate

This technique is indicated for moderate deformity in the proximal or distal femur. A common use of this technique is for correction of a distal femur valgus deformity with an open wedge correction and insertion of a locked plate. Other indications include varus deformity of the distal femur and proximal femur malunion. In the tibia, acute correction is used to correct moderate varus deformity of the proximal tibia with an open wedge correction and insertion of a locked plate. Other indications include angular deformity correction of the distal tibia and realignment of the ankle.

Acute Deformity Correction and Insertion of Intramedullary Rod

This approach is indicated for correction of rotational and/or angular deformity in the diaphysis of the femur. This is indicated for a patient with congenital femur malrotation or for a malunion after trauma. While this can be done in the tibia, it carries a greater risk of compartment syndrome and nerve injury.

Limb Lengthening with Internal Lengthening Intramedullary Rod

This approach is indicated for leg length discrepancy (LLD) and can be done in the femur or tibia. Acute correction of moderate deformity may be done followed by gradual lengthening. In the femur, the IM rod can be inserted antegrade or retrograde.

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Table 45.1 OSTEOTOMY TYPES WITH SURGICAL AND REHABILITATION NOTES

Location	Fixation	Acute/Gradual Correction	Diagnosis/ Etiology	Goal of Surgery	Surgical Notes	Rehabilitation Guidelines
Proximal femur	Plate	Acute	Malunion	Rotational and angular deformity correction	Use blade plate	PWB for 6 wk; hip ROM
Femur diaphysis	IM rod	Acute	Malunion, congenital	Rotational and angular deformity correction	Percutaneous osteotomy and rod insertion	WBAT; hip and knee ROM
Distal femur (DFO)	Plate	Acute	Arthrosis, knee deformity	Angular deformity correction	Use locked plate	PWB for 6 wk; knee ROM
Middle to distal femur	Internal lengthening rod	Gradual	LLD, deformity Malunion, congenital	Equalization of leg lengths and correction of deformity	Can do acute correction of angular and rotational deformity	PWB for 3–4 mo, hip extension, knee ROM
Middle to distal femur	External fixation	Gradual	LLD, large deformity Malunion, congenital	Equalization of leg lengths and correction of deformity	Can do acute correction of angular and rotational deformity	WBAT; hip extension, knee ROM
Proximal tibia (PTO)	Plate	Acute	Arthrosis, knee deformity	Correction of deformity	Correct varus deformity <10°	PWB for 6 wk; knee ROM
Proximal and middle tibia	External fixation	Gradual	Tibial deformity and LLD, arthrosis, knee deformity	Equalization of leg lengths and correction of deformity	Used for complex or large deformity	WBAT, knee and ankle ROM, especially knee extension, ankle DF
Middle tibia	Internal lengthening rod	Gradual	LLD	Equalization of leg lengths		PWB for 3–4 mo, knee and ankle ROM, especially knee extension, ankle DF
Distal tibia (SMO)	Plate	Acute	Ankle deformity Malunion, congenital	Correction of deformity	Correct varus or valgus of <10°	PWB for 6 weeks, ankle ROM
Distal tibia	External fixation	Gradual	Ankle deformity Malunion, congenital LLD	Equalization of leg lengths and correction of deformity	Used for complex or large deformity	WBAT, ankle ROM, especially DF

DF = dorsiflexion of ankle, DFO = distal femoral osteotomy, IM = intramedullary, LLD = leg length discrepancy, PTO = proximal tibial osteotomy, PWB = partial weight bearing, ROM = range of motion (active and passive), SMO = supramalleolar osteotomy, WBAT = weight bearing as tolerated.

Lengthening and/or Gradual Deformity Correction with External Fixation

This approach is indicated in children with open growth plates and for patients who have narrow IM canals or deformity, for whom an IM rod is contraindicated. This is also indicated for patients with large deformity for whom acute correction would be dangerous. Patients with infection, or poor soft-tissue envelope, are indicated for external fixation. The external fixator also allows fine-tuning of deformity correction after surgery is complete. This can be helpful in complex situations in which the goal is to achieve a plantigrade foot. Patient feedback regarding the position of the foot while the patient is standing can be very reliable.

Bone Transport with External Fixation

When there is bone loss from infection, trauma, or tumor, limb salvage reconstruction can be accomplished with bone transport. The bone defect is closed by opposing the adjacent bone ends. The limb shortening is treated with lengthening of the bone in a different location (Table 45.1).

REHABILITATION CHALLENGES

Femur

After reconstruction of the femur, the main focus is on knee motion. Patients will lose terminal extension and flexion without a diligent exercise program. Exercise to maintain hip motion is also important. The rehabilitation goal is to maintain hip and knee ROM and to strengthen the muscles around the hip and knee (Figures 45.1 and 45.2). Both active (AROM) and passive ROM (PROM) are needed (Figure 45.3).

Partial weight bearing is allowed until there is adequate consolidation of bone radiographically. Passive extension of the hip is achieved with manual stretching and by spending time in the prone position (5 minutes, four times per day) (Figure 45.4). PROM of the knee to maximize extension and flexion (Figure 45.5) is prescribed (15 repetitions four times per day). Passive stretches are held for a count of 5 seconds.

Tibia

After reconstruction of the tibia, the main focus is on knee and ankle motion. Patients will lose terminal motion of knee and ankle, especially knee extension and ankle dorsiflexion, without a focused exercise program. The rehabilitation goal is to maintain knee and ankle ROM (AROM and PROM) and to strengthen the muscles around the knee and ankle.

Partial weight bearing is allowed until there is adequate consolidation of the bone. AROM and PROM of the knee and ankle are prescribed. The focus is on passive ankle dorsiflexion and knee extension (15 repetitions four times per day) (Figures 45.6 and 45.7). Splinting the knee in extension and the ankle in dorsiflexion may be needed when risk of contracture is high.

External Fixation

External fixation pins pierce skin and other soft-tissue structures. This increases the difficulty of maintaining adjacent joint

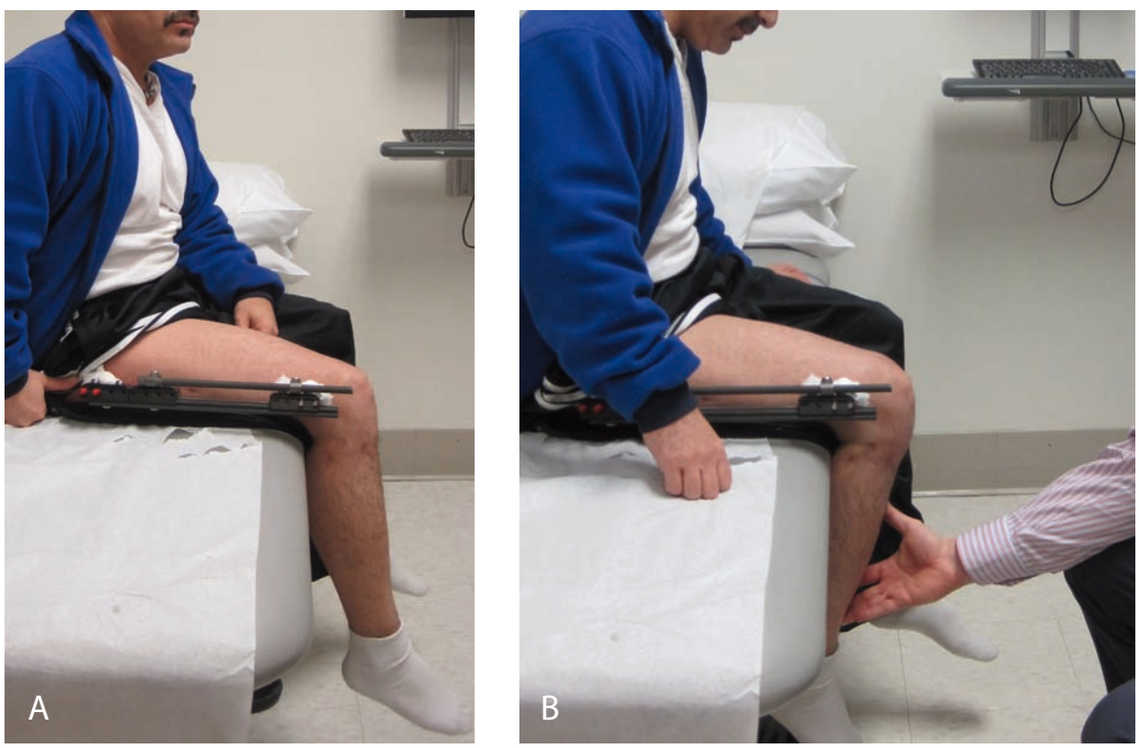


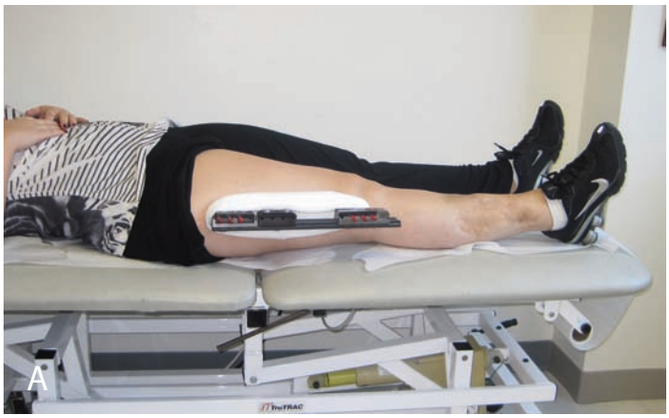
Figure 45.1 **A**, Photograph of desirable resting position after femur osteotomy with knee at 90° of flexion and foot dangling. This helps the patient maintain knee flexion. **B**, Photograph of passive flexion greater than 90° by therapist after femoral osteotomy.

Figure 45.2 **A**, Photograph of passive knee flexion using the other leg while seated in a chair after femoral osteotomy. The foot is resting on the floor. **B**, Photograph of passive knee flexion using the contralateral leg after femoral osteotomy with the leg dangling over the side of the bed. **C**, Photograph of passive extension of the knee using the contralateral leg after femoral osteotomy.

ROM. Upon completion of the surgical procedure, it is ascertained that there is full unencumbered ROM of joints. Pain and a hesitancy to move the joints is what leads to subsequent joint stiffness. Furthermore, the shape of the external fixator may naturally put the joint into a flexed position when resting. For example, a circular frame on the leg naturally puts the knee into flexion when resting supine. Pacing a bump under the foot is needed to maintain the knee in full extension. With low-profile internal fixation, this problem is less challenging. In general, patients are allowed to be weight bearing as tolerated (WBAT) after external fixation. This is not the case for plate fixation where weight bearing is usually protected for the first several weeks after surgery. These challenges are further increased with limb lengthening.

Limb Lengthening

Distraction is typically done 1 mm per day. The challenges outlined earlier are increased when lengthening is done. While muscle does have the ability to stretch and grow, typical patterns of stiffness are expected. During tibia/fibula lengthening, the gastrocnemius-soleus complex becomes increasingly tight, leading to a loss of knee extension and a loss of ankle dorsiflexion (DF). Exercise aimed to extend the knee and dorsiflex the ankle is mandatory. Both AROM and PROM are needed.



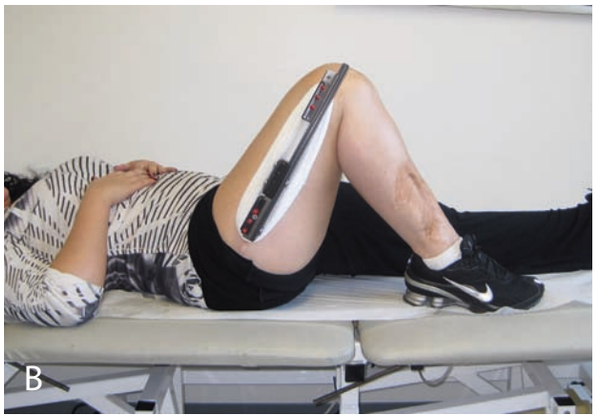
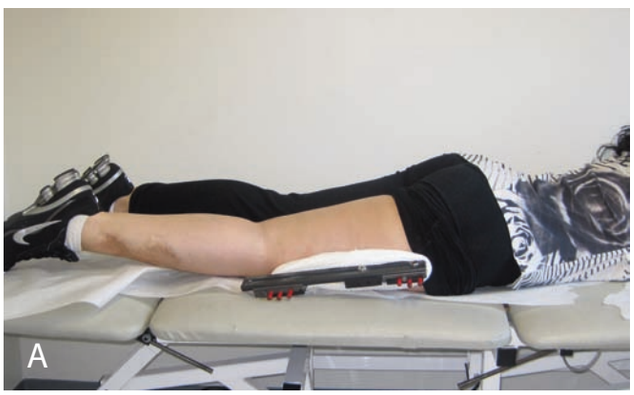


Figure 45.3 **A**, Photograph of the knee in full extension after femoral osteotomy is the supine position. **B**, Photograph of the heel slide actively done by the patient. This works on active hip flexion and active knee flexion. This is an exercise done 2 to 3 weeks after femoral osteotomy. **C**, Photograph of the leg lift. This works on active hip flexion and isometric quadriceps. This is an exercise done 3 to 4 weeks after surgery.



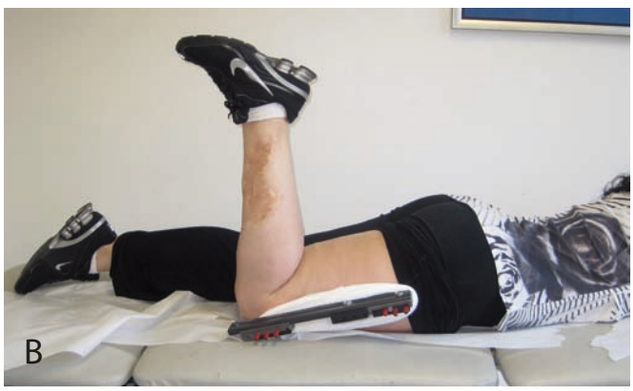


Figure 45.4 **A** and **B**, Photographs of prone knee flexion after femoral osteotomy. This can be done both passively at first and then actively. This stretches the rectus femoris and the hip flexors.

Figure 45.5 Photograph of the resting position of the knee in maximum extension by placing a bump under the ankle after femoral osteotomy. The bump under the ankle elevates the knee and calf from the table, encouraging full extension at the knee.

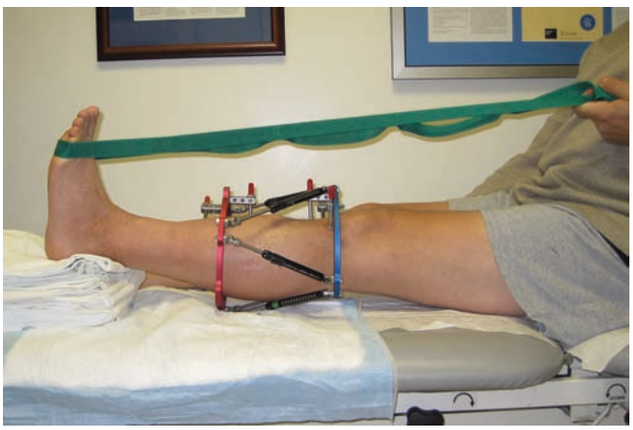
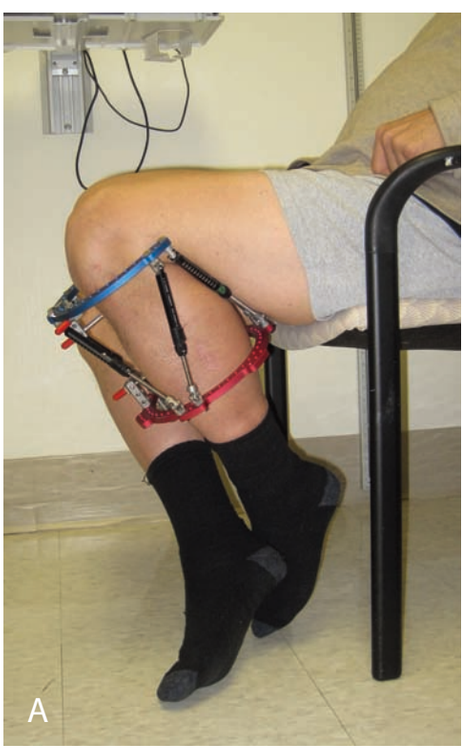


Figure 45.6 Photograph of passive dorsiflexion of the ankle with a strap after tibial osteotomy. A bump is under the ankle, lifting the rings off the table to keep the knee in extension, which is desirable resting as well.

During femur lengthening, the hamstrings, quadriceps, iliotibial band (ITB), and rectus femoris become increasingly tight. Exercises to maintain knee extension, knee flexion, and hip extension are mandatory. If there is knee instability, such as in a congenital case, loss of knee extension can lead to posterior subluxation. Excessive ITB tightness can lead to valgus deformation at the knee. Excessive tightness of the rectus femoris and quadriceps can lead to extension contracture of the knee and flexion contracture of the hip. These challenges are further increased with external fixation.

Internal Lengthening Intramedullary Rod

There are fewer joint ROM challenges with internal lengthening over a rod than with external fixation. Without the soft-tissue tethers of external fixation pins, there is much better maintenance of joint ROM during distraction compared to patients treated with external fixation. While this is a big advantage in both the femur and the tibia, the improvement is more significant in the femur. Weight bearing must be protected until there is sufficient consolidation of the bone to



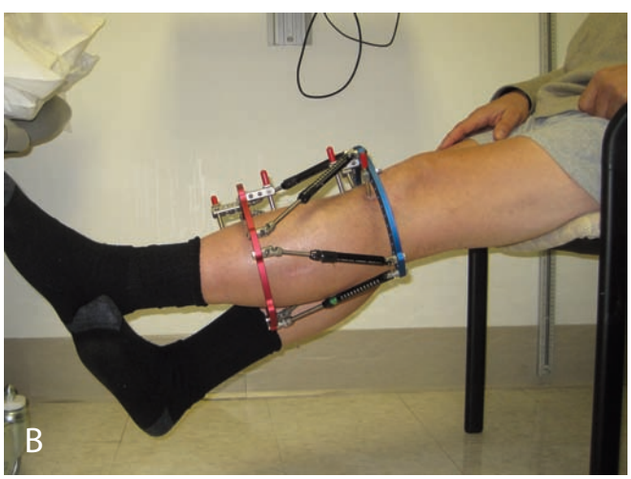


Figure 45.7 **A** and **B**, Photographs of passive knee flexion and extension after tibial osteotomy using the contralateral leg.

Table 45.2 REHABILITATION CHALLENGES AFTER OSTEOTOMY

Osteotomy Surgery	Rehabilitation Challenges
Femur	Knee and hip ROM, especially knee flexion and hip extension
Tibia	Knee and ankle ROM, especially knee extension and ankle dorsiflexion
External fixation	Soft-tissue tethering and pain from pins increases the likelihood of stiffness
Limb lengthening	Stretching of muscles increase likelihood of stiffness patterns noted above
Internal lengthening IM rod	Joint ROM less of a challenge compared to external fixation. Protected weight bearing needed for longer time than with external fixation

IM = intramedullary, ROM = range of motion (active and passive).

avoid implant failure. AROM and PROM of the adjacent joints is necessary (Table 45.2).

ADJUVANT SOFT-TISSUE PROCEDURES

Quadricepsplasty

When patients lose knee flexion to less than 60° despite rehabilitation, we perform quadricepsplasty to increase knee flexion. This would be done at the end of the distraction phase of lengthening via a limited quadricepsplasty, in which only the ITB and the vastus intermedius tendon are released. Weight bearing and the AROM and PROM knee regimen are not limited by this surgical intervention.

Iliotibial Band Release

We routinely perform an ITB release for femoral lengthening of greater than 1 inch at the time of the initial surgery. While this is most helpful in cases of congenital etiology, we also find it helpful in posttraumatic conditions. This is a tight band of tissue that resists distraction, and we have found that it lengthens as the bone lengthens. No defect in the ITB results from this intervention. This procedure does not affect the rehabilitation program.

Gastrocnemius-soleus Recession (GSR)

When patients lose critical ankle DF, we perform a gastrocnemius-soleus recession (GSR). This is often needed if tibia lengthening is greater than 4.2 cm and/or lengthening is greater than 13% of the original tibial length. Congenital etiology is also a factor that increases likelihood of needing GSR. GSR is performed through a posterior approach at the mid-distal third of the leg, during which the gastrocnemius and soleus fascia as well as the median raphe are transversely incised. This does not affect the weight-bearing status or the rehabilitation program. This can be done at the index surgery in a preventive manner or at the end of the distraction once a contracture develops.

SUMMARY

While there are specifics to each bone and technique used (Table 45.2), there are some general themes that can be summarized. After surgery, the early goals are ambulation within the safe range. This usually starts as partial weight bearing and progresses to WBAT once there is adequate bony consolidation. ROM of the adjacent joints is an important early focus; we prescribe AROM and PROM. Passive stretching to avoid predictable contractures is especially important during the distraction phase of bone lengthening when muscle tendon units will become tight. PROM is done early and progress is made to AROM against gravity a few weeks later. As the patient moves into the consolidation phase, weight bearing is advanced and strengthening programs are added to optimize recovery.

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