TECHNIQUE

Proximal Tibial Osteotomy for Medial Compartment Osteoarthritis of the Knee Using the Ilizarov Taylor Spatial Frame

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ABSTRACT

Medial compartment arthritis of the knee is a common problem that is typically associated with varus alignment and a weight-bearing axis that lies in the medial compartment. Knee flexion or hyperextension deformity or ligamentous instability may also be present. The young patient who is not an ideal candidate for total knee replacement may benefit from proximal tibial osteotomy for pain relief. The Ilizarov method with the Taylor spatial frame (TSF) is a powerful tool for accomplishing proximal tibial deformity correction. A specialized feature of the TSF is its virtual hinge, which allows for the simultaneous correction of multiplanar deformities and the stabilization of the ligament-deficient knee. The power of the spatial frame lies in its precise control over final limb alignment and in its ability to perform a residual correction. The stability of the ringed construct permits early weight-bearing and provides an ideal environment for new bone formation and a rapid healing response. Classic Ilizarov principles are followed to ensure proper frame application, while the Web-based computer program directs the gradual correction process. Patient involvement is crucial to the success of this technique. Computer-generated schedules and easy-to-read struts greatly simplify adjustments for patients. The most common complication is pin tract infection, which is adequately treated with a course of oral antibiotics in nearly all cases. The purpose of this report is to describe the advantages of this method of realignment and the basic technique used to perform the correction.

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HISTORICAL PERSPECTIVE

Operative realignment of the proximal tibia was described in 1800 by Sir Robert Jones who used a closing wedge osteotomy for the correction of tibia vara in children. Jackson reported success with this osteotomy in adults patients with osteoarthritis associated with varus knee alignment. Coventry refined and popularized the high tibial osteotomy technique, and good results have been obtained using this method.[1–4] Closing wedge osteotomies, however, have been associated with problems including an increased incidence of patella baja and loss of tibial inclination, both of which result in a difficult conversion to total knee arthroplasty.[5] Other obstacles include tibial bone loss, a lack of accuracy, and the inability to alter residual angular deformity postoperatively.[6–10]

Owing largely to the work of G. A. Ilizarov, distraction osteogenesis has gained worldwide recognition as a versatile technique for correcting a host of bony abnormalities. The application of this gradual realignment method toward the treatment of medial compartment gonarthritis has been undertaken with great success.[11–14] With the use of gradual correction techniques, problems leading to difficult conversion to knee arthroplasty typical of closing wedge osteotomy are minimized. The ability to alter the fixator in the postoperative period to improve limb alignment has been one of the most appealing aspects of using external fixators with osteotomies.

Both monolateral external fixators and Ilizarov ringed fixators have been designed to perform gradual limb realignment. Unilateral frames are comfortable and well tolerated by patients. They are lightweight and fit under most clothing, making them less conspicuous. However, unilateral frames are less versatile than circular fixators and do not allow for the correction of complex deformities.[15] At our institute, monolateral frames are used in conjunction with proximal tibial osteotomy for the gradual correction of varus tibial deformity not associated with other bony or soft tissue abnormalities.

When compared with monolateral fixators, Ilizarov ringed external fixators offer increased stability.[15] This may decrease the incidence of early loss of correction, a known complication of all methods of tibial osteotomy. The traditional Ilizarov frames allow for the correction of multiple deformities through a common osteotomy site performed as separate steps of a staged procedure. These fixators are technically demanding but have yielded good results avoiding many of the complications of the Coventry osteotomy.[14,16]

The Taylor spatial frame (TSF) has been used in the treatment of medial compartment pain associated with varus malalignment. The strut adjustments are easy to perform, and the computer-printed schedule is relatively simple for patients to follow. The TSF is far more forgiving than the traditional Ilizarov ringed system. The spatial frame's virtual hinge can be precisely controlled by the computer, drastically reducing time spent on preoperative calculations and on intraoperative hinge positioning. A great strength of the TSF lies in its ability to correct large varus deformities and multiplanar deformities. The TSF can simultaneously incorporate and correct varus malalignment with flexion deformity and internal or external rotation deformity. Lengthening or shortening at the osteotomy site may be added as well. Residual deformity remaining at the termination of the correction with a TSF requires only a simple schedule adjustment without any need for further surgery or changes in the frame construct. A residual program can also be run once the desired alignment is obtained to provide compression across the osteotomy for enhancement of bony healing.[17] Disadvantages of circular fixation include the bulk of the frames, the need for meticulous pin care of multiple sites, discomfort related to the use of tensioned wires, and the need to perform a fibular osteotomy in most cases.

INDICATIONS AND CONTRAINDICATIONS

The ideal candidate for the proximal tibial osteotomy is a patient younger than 60 with complaints of isolated medial joint line pain exacerbated by weight-bearing activities. Radiographs demonstrate medial compartment arthritis and varus alignment. Patients are counseled that the goal of this surgery is to alleviate the medial pain and slow the progression of further damage to the medial compartment articular cartilage. The most compelling indications for the use of the TSF in conjunction with proximal tibial osteotomy include patients with large and complex deformities about the knee joint, ligamentous laxity, or limb shortening. (Fig. 1).

In patients with knee flexion contracture and flexion deformity of the proximal tibia, the addition of extension at the osteotomy will correct this deformity, allowing for full extension. Anterior cruciate ligament deficiency associated with medial gonarthritis leads to anterior tibial subluxation. The instability can be decreased by increasing the posterior proximal tibial angle[18] from 81° to 90°.[19] In patients found to have internal or external tibial torsion deformities, these axial malalignments can also be corrected simultaneously through the same osteotomy site, further expanding the indication for TSF. Patients with laxity of the posterolateral ligaments will benefit from use of the TSF. Whereas closing wedge osteotomy increases the relative length of the lateral ligaments, an opening wedge osteotomy affords us the ability to retension these lateral ligaments. This is carried out by lengthening the tibia without performing a fibular osteotomy or securing the proximal tibiofibular joint. The fibula will migrate distally, tightening the lateral ligamentous structures.

Patellofemoral compartment arthritis has been considered a relative contraindication for proximal tibial realignment. Although many patients with medial gonarthritis experience anterior knee discomfort related to patellofemoral chondromalacia, many authors note that the presence of Outerbridge grade III–IV changes of the patellofemoral articular surfaces has not affected the final outcome after High Tibial Osteotomy (HTO).[1,12,20]

The presence of lateral compartment disease has classically been taught to jeopardize the results after HTO. Miller and Sterett have observed that gradual correction to neutral alignment of the varus arthritic knee containing small areas of grade IV chondromalacia laterally has yielded reliably good results.[12]

PREOPERATIVE PLANNING

All patients are clinically evaluated by history and physical examination. Special attention is directed toward the assessment of leg length, knee ligamentous stability, and rotational alignment as correction of these parameters using the TSF may be added to the varus realignment. Gait is carefully evaluated to assess lower extremity function looking for abnormal kinematics. An erect anteroposterior 51-in radiograph of both lower extremities on one cassette, standing anteroposterior, lateral, and merchant

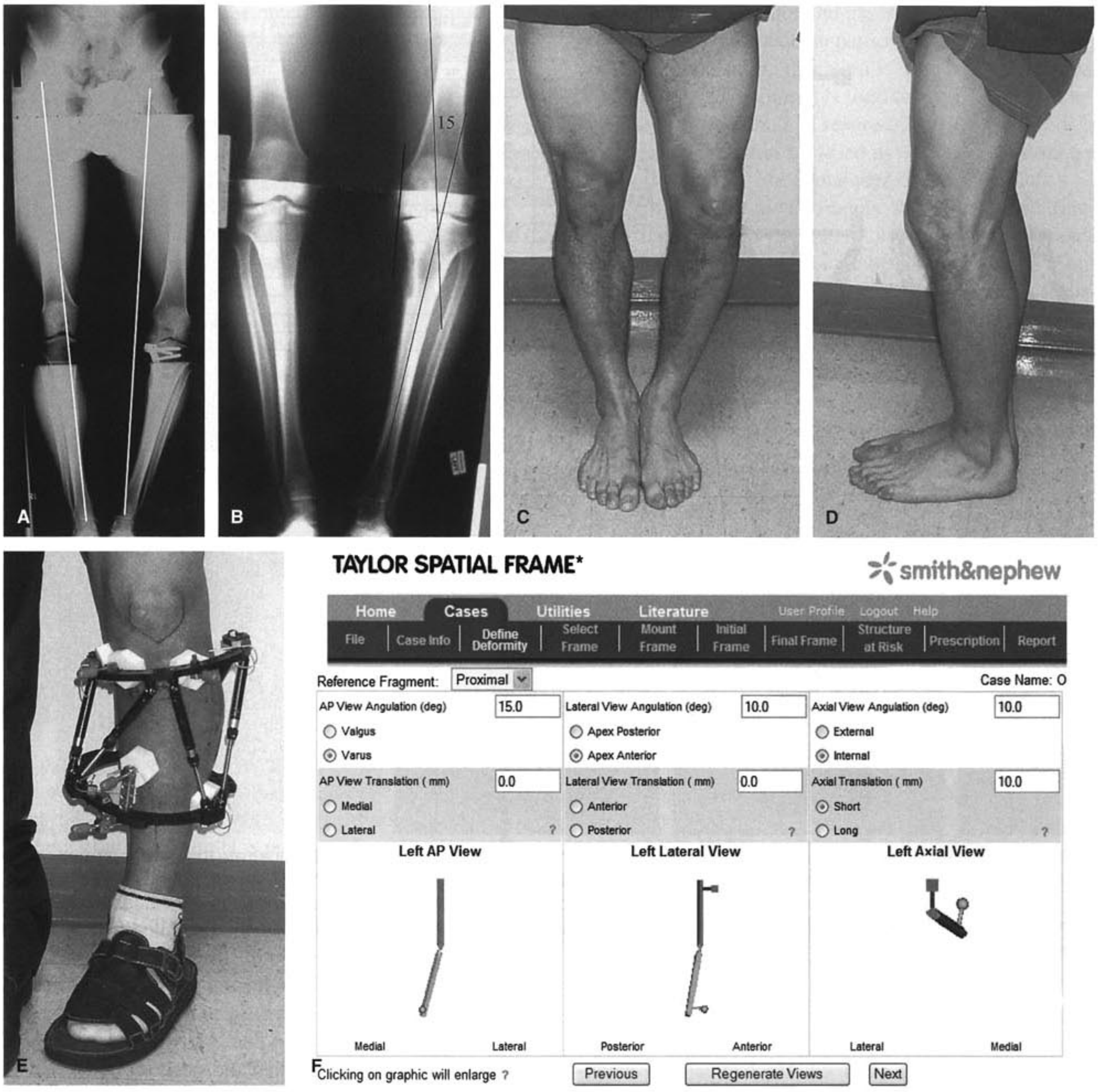


FIGURE 1. Case example of 37-year-old man with medial compartment arthritis after a medial plateau fracture. A, Erect 51-in bipedal radiograph showing the center of the hip and ankle joints on one cassette. The left lower extremity has a medial mechanical axis deviation of 37 mm. B, Standing anteroposterior radiograph of bilateral lower extremities. The left lower extremity has 15° of varus deformity (medial proximal tibial angle is 80° and joint line convergence angle is 5°). Advanced medial compartment degeneration is apparent. C and D, Frontal and lateral views demonstrating varus and flexion deformity. E, Early postoperative photograph before the strut adjustment period. Internal rotation deformity is appreciated with the patella facing forward. F, The deformity data are entered into the Web-based computer program, and an image is generated, recreating the deformity. (With reference to the stick diagrams, the square represents the knee and the circle the foot.)

(continued on next page)

G H

Prescription

Date	Day	Strut 1 ● (Red)	Strut 2 ● (Orange)	Strut 3 ● (Yellow)	Strut 4 ● (Green)	Strut 5 ● (Blue)	Strut 6 ● (Violet)	View
10/15/02	0	171	162	174	159	136	119	View
10/16/02	1	171	162	174	159	138	122	View
10/17/02	2	170	162	173	160	140	125	View
10/18/02	3	170	162	173	160	142	128	View
10/19/02	4	169	162	172	161	144	131	View
10/20/02	5	169	162	172	161	146	134	View
10/21/02	6	168	162	171	162	148	137	View
10/22/02	7	168	162	171	162	150	140	View
10/23/02	8	167	163	171	163	152	143	View
10/24/02	9	167	163	170	163	154	146	View
10/25/02	10	166	163	170	163	156	149	View
10/26/02	11	166	163	169	164	158	152	View
10/27/02	12	165	163	169	164	160	155	View
10/28/02	13	165	163	168	165	162	158	View
10/29/02	14	164	163	168	165	164	161	View
10/30/02	15	164	163	167	166	166	164	View
10/31/02	16	163	163	167	166	168	167	View

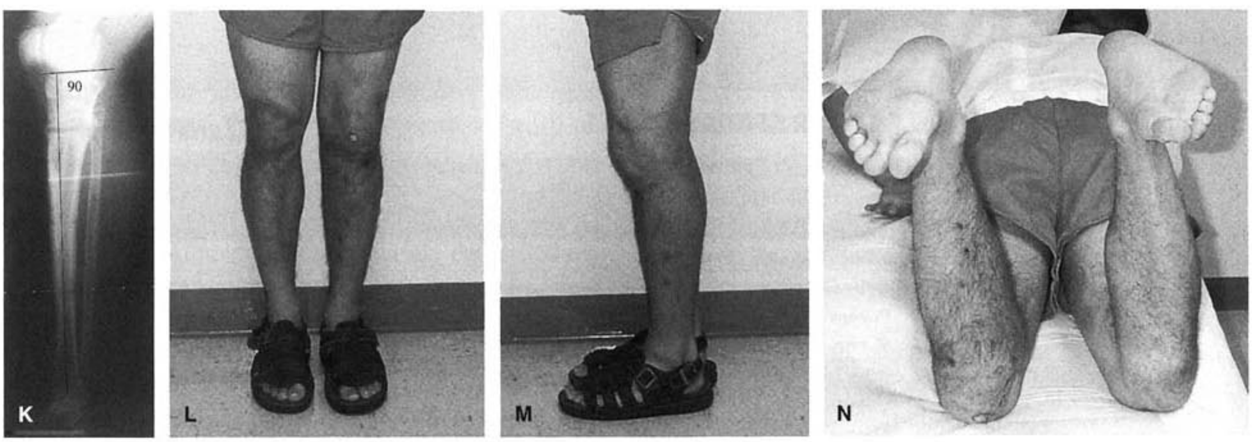
Strut Change-Outs

Change-Out	Strut	Overlap Interval		Strut Change	
		First Day	Last Day	From	To
No strut change-outs are required.					

I

Previous Next

J



K L M N

FIGURE 1. G and H, Anteroposterior and lateral computer animation images, respectively, illustrate the deformity with frame in place. I, The prescription indicates the appropriate strut settings for each day during the adjustment period. In this case the mechanical axis was corrected to the neutral position. J and K, Three months after frame removal, the valgus and sagittal alignment is maintained. L and M, Full correction of varus and flexion deformities. N, Symmetric thigh foot axis indicates correction of the internal rotation deformity.

views of the knee are obtained. Mechanical axis deviation is determined using the malalignment test.[19] Values for the lateral distal femoral angle, medial proximal tibial angle, and joint line convergence angles are measured to localize sources of deformity. Sagittal deformity is evaluated on the lateral radiographs. The center of rotation of angulation (CORA) is located and the magnitude of deformity measured.[19] A correction of this magnitude of deformity will result in a neutral mechanical axis. At times this is desirable, but more often valgus realignment is sought. The postoperative goal is to unload the medial compartment. This is reliably achieved by realigning the distal tibia such that the mechanical axis passes through the lateral compartment. Fujisawa et al described an ideal target point for the mechanical axis one-third of the distance from the knee center across the lateral plateau.[21] Jakob and Murphy modified the position of this point based on the degree of medial articular cartilage damage. The medial third of the lateral tibial plateau is itself divided into thirds. If the extent of degeneration of the medial compartment is minimal, then the goal will be correction of the mechanical axis through the medial third (one-third of the distance to Fujisawa's point). If the medial compartment damage is more advanced, then the goal will be overcorrection of the mechanical axis through the middle third. With severe arthrosis of the medial compartment, the mechanical axis is shifted to pass through Fujisawa's point.[22] We use Fujisawa's point with Jakob's modifications to guide final alignment. To complete the planning, a new mechanical axis line is drawn through the desired point in the lateral compartment and the magnitude of deformity is remeasured in the frontal plane. These values will be entered into the computer to ensure that the distal fragment will be well aligned at the completion of the adjustment period.

Often we will recommend a simple knee arthroscopy prior to osteotomy or in conjunction with the osteotomy. The arthroscopic procedure serves as an excellent tool for evaluating the integrity of the lateral and patellofemoral compartments as well as providing an additional opportunity to treat mechanical symptoms originating from the medial compartment. The extent of degenerative change in the medial compartment encountered at arthroscopy may provide additional information with regard to the patient prognosis. Arthroscopy also provides an opportunity to perform abrasion arthroplasty of the degenerated articular surfaces. It has been observed that eburnated and abraded surfaces in combination with proximal tibial realignment form new cartilage more readily than those covered by fibrillated cartilage.[23–25]

Osteotomy of the fibula is required in most patients undergoing proximal tibial osteotomy with use of the TSF. This is primarily because those patients for whom the TSF is indicated undergo large varus corrections or corrections of multiple deformities that rely on a mobile fibula.

■ TECHNIQUE

The patient is taken to the operating room and placed supine on a radiolucent operating table. Sheets are placed under the ispilateral pelvis to internally rotate the lower extremity until the patella is pointing directly toward the ceiling. At our center, regional epidural anesthesia is typically used to provide analgesia for the surgery. A dose of prophylactic antibiotics with gram-positive coverage is given in the operating room prior to skin incision. C-arm fluoroscopy is used throughout the procedure to ensure ideal positioning of the fixator and allow for the implementation of minimally invasive techniques. The C-arm is positioned on the side of the contralateral leg. If a lengthening, rotational correction, flexion correction, or significant translation of the distal fragment is planned, then a fibular osteotomy is necessary. This is carried out under tourniquet and is performed at the middiaphyseal level. When varus is being corrected, an oblique osteotomy is made, allowing the fibula to shorten as the cut bone ends slide past one another. If rotation is being corrected, then a transverse fibular osteotomy with a minor resection can be performed, allowing the bone ends to translate and shorten. A direct approach is made to the fibula through the interval between the peroneal muscles and the soleus. Care is taken when performing the subperiosteal dissection as the motor branch to the Extensor Hallucis Longus lies close to the anteromedial border of the fibula. The soft tissue is protected with Hohman retractors while the fibular diaphysis is cut with an oscillating saw. Frequent pauses are made during sawing, and liberal saline irrigation is used to diminish heat production. An osteotome is used to ensure that the medial cortex of the fibula is severed (Fig. 2). The fascia is left open, and the skin is closed in layers. The tourniquet is then deflated for the remainder of the operation.

The technique used to apply the TSF is the "rings first" method as opposed to using a preconstructed frame. We favor this technique because it frees the rings for ideal placement on the leg with regard to the soft tissues. The tourniquet is not recommended for this portion of the surgery as adequate blood flow is needed to cool wires and drills as they pass through the tibia. A review of the anatomic safe zones for wire passage through the tibia should be performed prior to surgery. With use of the fluoroscopic anteroposterior projection, a smooth 1.8-mm Ilizarov wire is advanced across the proximal tibial metaphysis from lateral to medial parallel to the joint line. This wire will ensure proper positioning of the proximal ring. The wire should start 14 mm distal to the lateral tibial plateau to remain out of the joint capsule.[14,26] Once this wire has been placed, the proximal ring is centered on the leg and positioned parallel to the joint surface (Fig. 3). The wire is tensioned to 130 kg in the standard fashion (Fig. 4). The anterior aspect of the ring should lie between one and two finger breadths from the tibial crest. We prefer to use a two-thirds ring proximally to accommodate posterior leg swelling and allow knee flexion. Having set the ring in the anteroposterior plane, attention is turned to the lateral projection. The ring is held in a position orthogonal to the proximal tibia in the sagittal plane as seen on lateral fluoroscopy. A second wire is placed through the fibular head exiting the anteromedial tibia. When placing wires through the fibular head, great care is taken to avoid damaging the

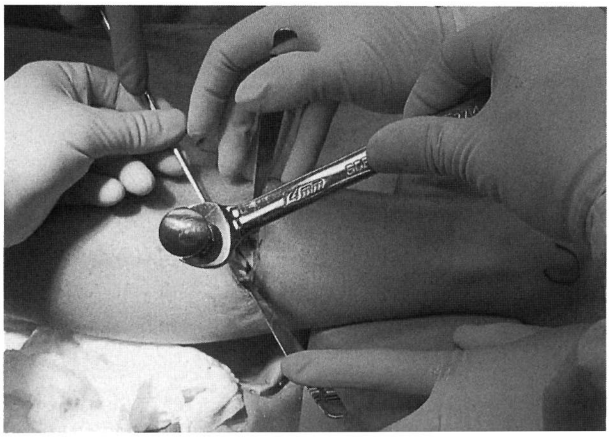


FIGURE 2. Fibular osteotomy is completed by rotating the osteotome with a 14-mm wrench.

FIGURE 3. The proximal ring should be mounted parallel to the joint surface on the anteroposterior projection. This orientation helps to overcorrect the varus alignment.

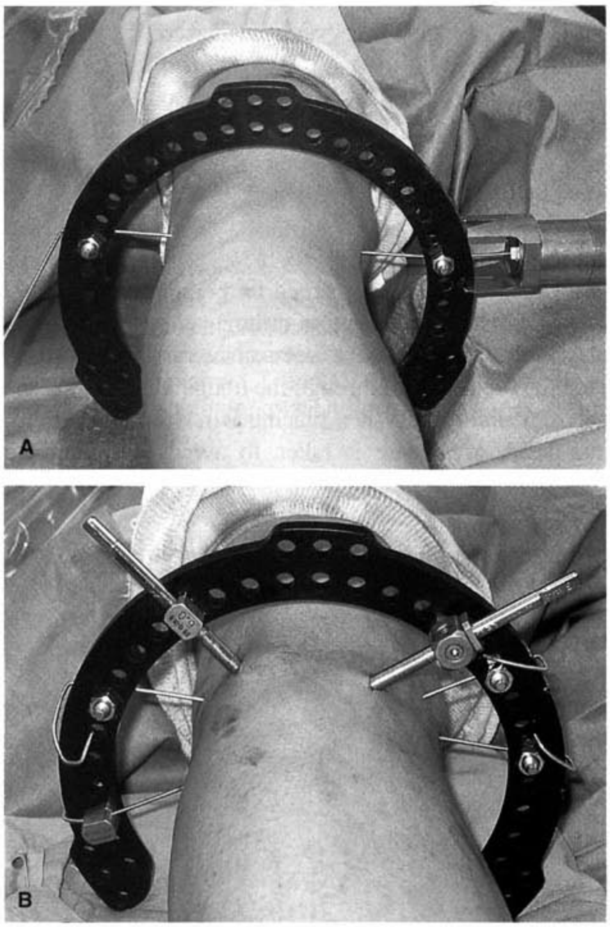


FIGURE 4. A, Reference wire is tensioned to the proximal ring, establishing frontal alignment. B, Typical configuration of proximal ring fixation block with two wires and two half pins.

peroneal nerve. The surgeon places the wire by hand onto the fibular head while the foot is observed for signs of movement indicating nerve impalement. The wire is then advanced and fixed to the ring. If the lateral ligaments are to be tensioned, then the fibular head is not captured with this second wire. A cortical threaded half pin is placed from anteromedial to posterolateral. We advocate the use of hydroxyapatite-coated half pins when performing this procedure on patients with osteopenia. These pins have been associated with a decreased incidence of loosening and subsequently a lower rate of pin site infection.[27] The pin is secured to the ring, and an additional half pin is placed anterolateral at Gerdy's tubercle to posteromedial (Fig. 5).

Once the proximal ring is secured, the mounting parameters are addressed. The mounting parameters are a set of measurements that inform the computer of the location of the reference ring with respect to the virtual hinge referred to as the Origin. The computer will need to know if the reference ring is anterior/posterior to the origin, medial/lateral to the origin, and proximal/distal to the origin and these exact distances in millimeters. For a proximal tibial osteotomy, the proximal ring is used as the reference ring. The distance from the center of this ring to the Origin in the coronal, sagittal, and axial planes is measured. The Origin can be positioned at the CORA of the deformity or at the center of the osteotomy site. If the center of the osteotomy site is used as the Origin, then one must typically add lateral translation to the deformity parameters to ensure restoration of the mechanical axis at the end of the correction. To determine mounting parameters, the center of the ring and the center of the proposed osteotomy site must be localized on the same C-arm image. The anteroposterior parameters are established by first closing the proximal two-thirds ring with a threaded rod and centering a nut on that rod. This will define the center of the posterior part of the ring. The corresponding center of the anterior aspect of the ring is marked by placing a threaded rod in the middle hole of the anterior master tab (see Fig. 5A). A three-hole rancho cube can be placed on the anterior threaded rod at the level of the proposed osteotomy. The C-arm is centered on the ring in the anteroposterior position until the ring is seen as a single line. The leg is then rotated under live image intensification until the anterior threaded rod overlaps the nut on the posterior rod (see Fig. 5B). This generates a picture well centered on the ring. The distance between the rancho holes and the center of the bone is recorded, and a direct measurement is taken on the frame with a ruler. The center of the frame is usually slightly lateral and proximal to the center of the osteotomysite. The lateral mounting parameters are taken in a similar fashion. A threaded rod is placed on the medial side of the ring in the center-most hole.

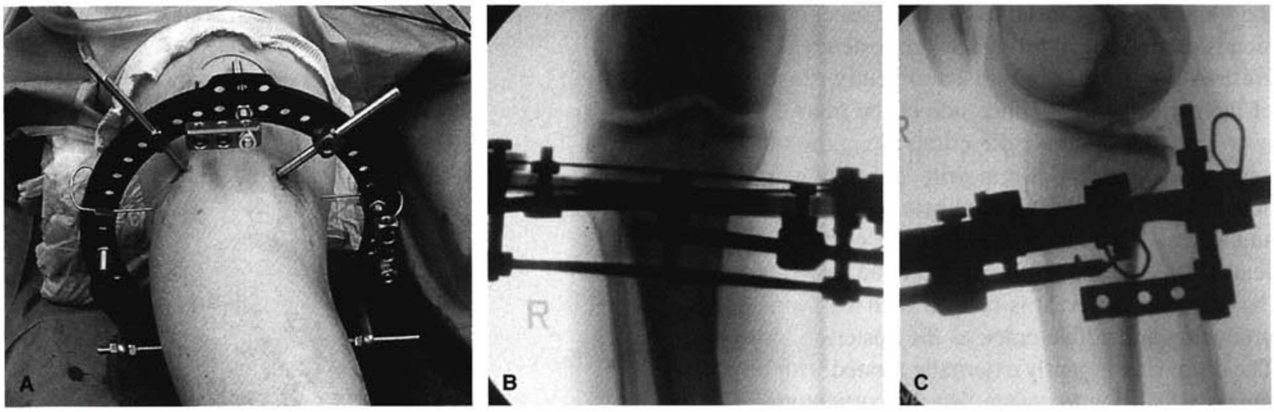


FIGURE 5. A, Anterior threaded rod is through the center of the ring, and the rancho cube is placed at the level of the origin. The ring is open posteriorly, and a long threaded rod is used to close the ring and establish a center point. A medial threaded rod with a rancho cube and a lateral threaded rod are seen at the midpoint of the ring as well. B, Anteroposterior fluoroscopy projection of central threaded rod and posterior threaded rod centered perfectly. The center of the ring is seen to be slightly lateral to the center of the tibia at the level of the proposed osteotomy (origin). C, Lateral image showing threaded rod with attached rancho cube. The rod marks the center of the ring in the sagittal plane and is perfectly overlapped with another threaded rod on the opposite side of the ring. The tip of the rancho is at the origin. This distance is measured directly on the frame and recorded in millimeters. The data will be entered as the center of the ring is posterior to the origin.

A second rod is placed on the lateral side in the corresponding hole. A three-hole rancho cube is secured onto the rod at the level of the proposed osteotomy. The C-arm is moved into a lateral position and aligned on the ring, making the ring appear as one line. The leg is then rotated under live image until the medial and lateral rods are aligned (see Fig. 5C). The distance from the threaded rod line to the center of the bone is recorded using the rancho cube holes as a reference. The actual distance is measured on the frame with a ruler. The center of the frame should be posterior to the origin. These values are recorded for later use in the creation of a schedule for strut adjustments.

Attention is then turned to the distal ring. Some thought should be given to determining the optimal distance between the rings. This will help minimize strut changes, which are an inconvenience to the patient and the surgeon. Typically medium struts are used, and they are set in the middle length position (145 mm). A medial face wire is advanced from lateral to medial across the tibia orthogonal to the long axis of the tibia. Care must be taken not to generate heat while advancing the wire through this cortical bone. Frequent pauses are prudent, and a wet sponge can be used to cool and guide the wire during its insertion. The distal ring is centered on the leg and fastened to the wire. The wire is tensioned to 130 kg. A strut can be used to hold the ring orthogonal in the sagittal plane. Once the ring position is set on the lateral view, two additional half pins are inserted proximal and distal to the distal ring, preferably out of plane, yielding a total of three points of fixation distally (Fig. 6). The six struts are attached to the proximal ring and tightened loosely. The struts are secured to the distal ring without introducing any tension or compression forces to the system. Free rotation of the struts should be possible as the shoulder bolts spin through the ring. The strut lengths are recorded, and all of the struts are detached from the proximal ring to carry out the tibial osteotomy.

The tibial osteotomy should be made distal to the tibial tubercle to prevent involvement of the extensor mechanism, but it should be proximal enough that it courses through cancellous metaphyseal bone to ensure reliable regenerate formation. The osteotomy we use is a percutaneous technique. A 1-cm incision is made over

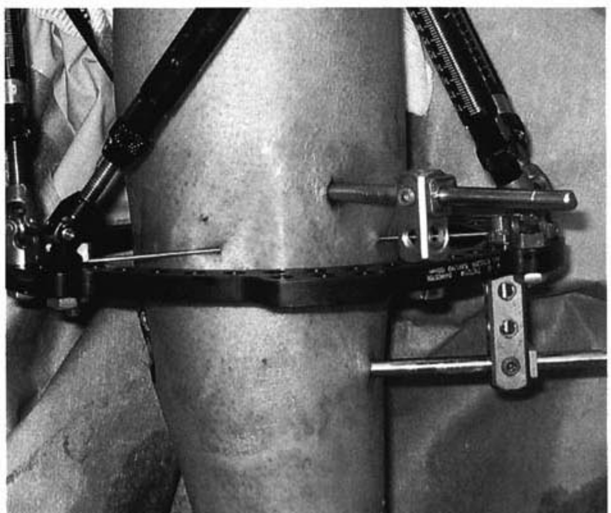


FIGURE 6. Typical set-up of distal ring with one wire and two half pins.

the tibial crest just distal to the tibial tubercle. The incision is carried down through the periosteum and onto the crest. A 5-mm elevator is used to gently raise a portion of the periosteum on either side of the tibia. The cortex is predrilled in multiple directions along the same transverse plane with a 4.8-mm drill. A 5-mm osteotome is advanced through the cortical bone of the tibia's medial and lateral faces (Fig. 7). When the osteotome is fully seated through the width of the bone and is engaging the posterior cortex, it is twisted with a 14-mm wrench, producing an audible crack as the posterior cortex fails. The distal ring is gently externally rotated with respect to the proximal ring to ensure that the corticotomy is complete (Fig. 8). The bone ends are reduced to their preosteotomy position, relieving stress on the periosteum and decreasing bleeding (Fig. 9). The struts are reattached to the rings at their previously measured lengths, stabilizing the osteotomy site (Fig. 10). The wound is closed with simple sutures, and the pin sites are dressed with Xeroform and sterile dressings. An Ace bandage is used to support the forefoot in a neutral position. The epidural is discontinued in the immediate postoperative period to avoid masking early signs of compartment syndrome. A latency phase of 10 days is used prior to the start of frame adjustments.

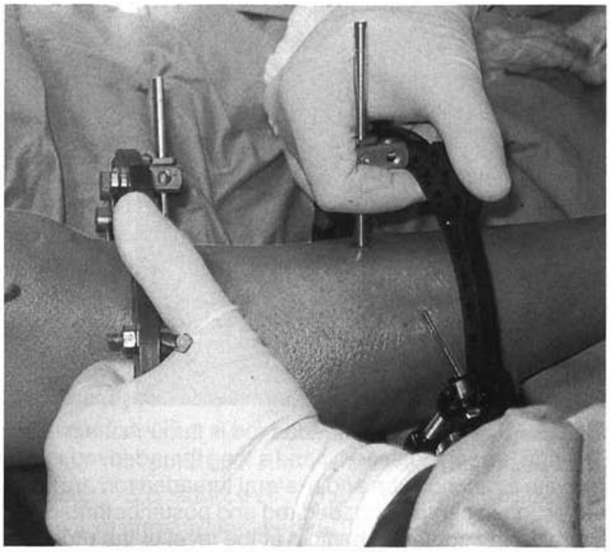


FIGURE 8. Rotational osteoclasis ensures a complete osteotomy. External rotation is thought to prevent tension on the peroneal nerve.

DISCUSSION

Distraction osteogenesis has been used by many authors in the context of proximal tibial osteotomy to obtain gradual correction of varus alignment. In a prospective randomized trial comparing closed wedge high tibial osteotomy with open wedge osteotomy by hemicallotasis, Magyar et al noted that undercorrection and overcorrection were relatively common complications of the Coventry-type osteotomy. This lack of accuracy led to a broad array of final alignments in the closing wedge group. This was not observed in their opening wedge hemicallotasis patients whose final alignment was

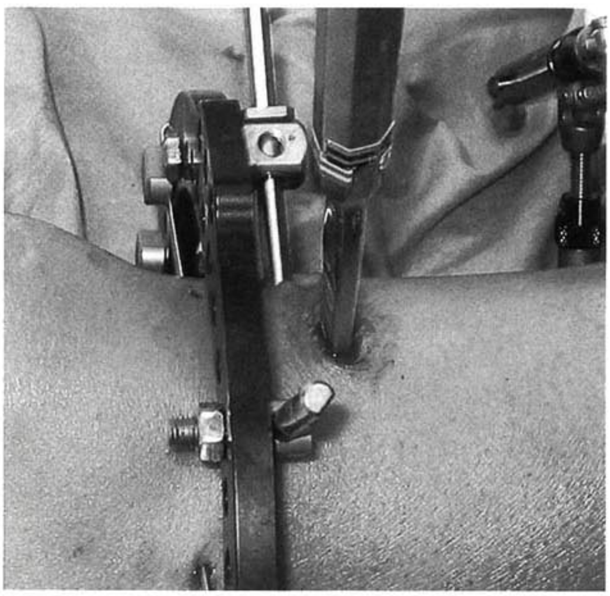


FIGURE 7. The osteotome is advanced through the small skin incision. The osteotome is twisted with the 14-mm wrench 90° and then rotated back to its original position, preventing displacement.

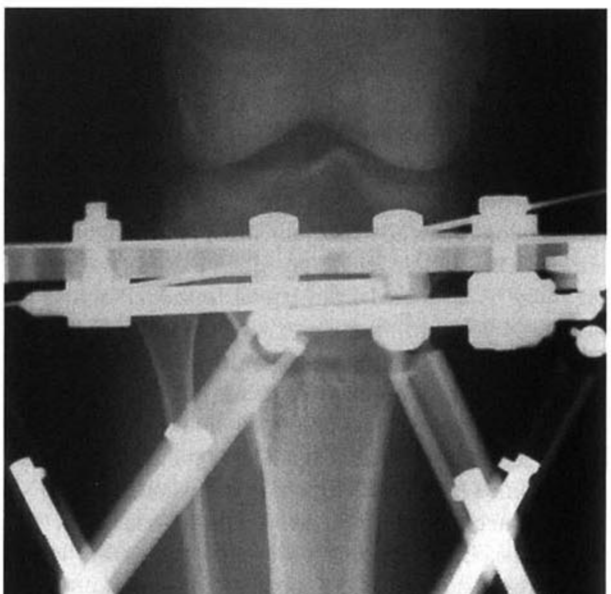


FIGURE 9. Anteroposterior radiograph demonstrating typical transverse osteotomy in a reduced position.

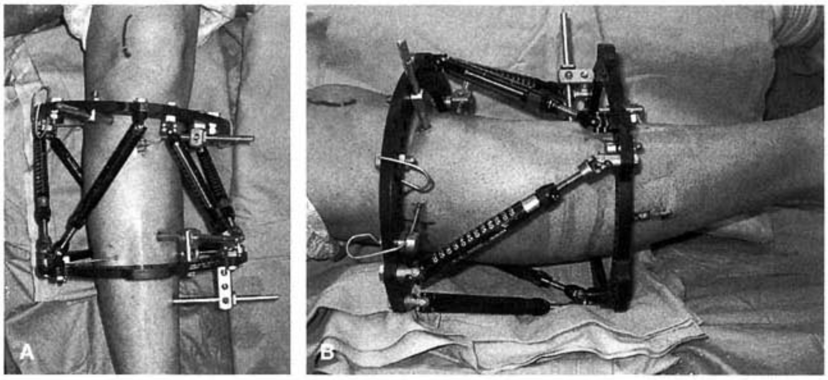


FIGURE 10. Frontal (A) and lateral (B) views of final frame position at the completion of surgery.

accurately controlled. Furthermore, they reported that rate of loss of correction over the first postoperative year was much higher in the closing wedge osteotomy group.[28]

Nakamura et al compared 50 knees undergoing proximal tibial osteotomy using either a dome osteotomy technique or a hemicallotasis method. The dome osteotomy was performed above the level of the tibial tubercle using acute correction and compression clamp fixation. In the hemicallotasis group, the osteotomy was performed below the tubercle, and correction was achieved gradually with external fixation. Significant postoperative shortening of the patellar tendon and decrease in the sagittal angle of inclination of the tibial plateau were observed in the dome osteotomy group but not in the hemicallotasis group.[5]

Sen et al looked at 53 patients undergoing high tibial osteotomy fixed with either internal fixation or external circular fixation. They found that those patients stabilized with external fixation demonstrated better results in terms of Hospital for Special Surgery score, alignment of the lower extremity, and preventing the progression of arthritis.[14]

In our clinical experience, proximal tibial osteotomy performed in conjunction with the TSF yielded good results in the treatment of pain and dysfunction associated with genu varum. Thirty-four patients with medial mechanical axis deviation and medial compartment degeneration were treated with this technique (unpublished data). Indications for this technique included severe genu varum ($>8°$) and associated deformities including rotational malalignment, shortening, flexion contracture, knee hyperextension, and ligamentous laxity or instability. In all patients, ideal alignment was restored. Short Form-36 scores improved an average of 16 points. There was a trend toward less improvement in patients with more severe arthrosis. In those patients with knee instability, there was subjective improvement in all cases. In our experience, we have noticed that the treatment was well tolerated and all patients were satisfied with their results.

COMPLICATIONS

Pin Infection

Pin site infection is a common complication that we encounter when using external fixation. Pin infections are marked by erythema, increasing pain, and drainage around the pin or wire. Most of these respond well to more aggressive local pin care and oral antibiotics. If the infection does not resolve quickly, then broader-spectrum antibiotics are added or the pin or wire is removed. More advanced infections are treated with removal of the pin or wire and local bone debridement in the operating room and intravenous antibiotics as needed. Loose pins and wires are removed and the pin sites debrided even in the absence of infection. Although the possibility exists that chronic osteomyelitis from an infected pin tract could lead to a future infected total joint arthroplasty, this complication has not been reported in the literature.

Premature Consolidation

Incomplete corticotomy can complicate proximal tibial osteotomy. A circumferential division of the tibial cortex may be ensured by rotating the proximal and distal rings in opposite directions and witnessing uninhibited motion through the corticotomy site. Other methods have been described, including acute distraction and angulation at the osteotomy site, but these techniques are more disruptive to the periosteum and not recommended.

True premature consolidation of the osteotomy is rare in the adult patient. Once the osteotomy is performed, there is a latency period of 7–10 days before any correction is attempted. If the latency period is prolonged, then the osteotomy site will consolidate prematurely. Similarly, if the correction is carried out too slowly, the osteotomy site may heal, preventing further correction.

Patient-Related Complications

The success of any gradual correction system is founded in the patients' ability to participate in their own care. Patients are responsible for performing their own strut adjustment three times daily at the outset of treatment. The TSF has simplified this process through color coordination and a precise numbering system. Even so, patients have made strut adjustment errors. These mistakes are usually quickly acknowledged and remedied. Patients need to be seen frequently during the adjustment period to avoid errors.

Nonunion

Osseous nonunion can complicate any osteotomy procedure. Causes may include inadequate fixation, lack of weight-bearing, smoking and other causes of poor blood flow to the extremity, patient comorbidities, too rapid a correction, poor osteotomy technique, and an osteotomy through diaphyseal bone. Nonunions are treated aggressively with a variety of methods including compression across the osteotomy site, percutaneous periosteal and endosteal stimulation, and additional points of fixation. Nonunions are rare when using the TSF technique. When there is impaired healing, this specialized frame provides ideal circumstances for effective treatment. We have not created nonunions using this method, but we have successfully treated several inherited nonunions of high tibial osteotomies with the Ilizarov method.

Deep Vein Thrombosis

Deep vein thrombosis (DVT) is always a concern with surgery of the lower extremity. Treatment is aimed at prevention. Patients are launched into early rehabilitation programs emphasizing immediate mobility to avoid venous stasis. There is no restriction to movement at the ankle, knee, or hip, and frame stability allows comfortable weight-bearing early in the postoperative period. In the hospital, patients receive subcutaneous low molecular weight heparin. Upon discharge, patients start a 1-month course of acetylsalicylic acid despite concerns about its effects on bone healing. With this regimen, we have not had any cases of DVT or pulmonary embolism.

■ POSTOPERATIVE MANAGEMENT

General

Patients are admitted to the hospital for 2–3 days. Nonsteroidal anti-inflammatory medications are avoided in all osteotomy patients for fear of adverse affects on bone formation. The patients receive intravenous antibiotics for 24 hours and are then switched to oral antibiotics. The patients are discharged on oral antibiotics for 10 days and oral pain medication. Patients return to the office 10 days postoperatively where sutures are removed and they are educated on how to perform strut adjustments. Patients are seen every 2 weeks during this adjustment period and then once monthly during the consolidation period.

Deformity Correction

Correction of the deformity begins after a latency period of 7–10 days. The Web-based Smith and Nephew program is used to generate a daily schedule for strut adjustments that the patient will perform at home. The computer requires the input of basic information including the side, the deformity parameters, the size of the rings and length of struts used, the mounting parameters measured during frame application, and rate of daily adjustment. Additionally, a structure at risk is selected and entered into the program to ensure gradual correction. For valgus-producing osteotomy, the structures at risk are the medial soft tissues as they are in the concavity of the correction and will be stretched the greatest distance. With use of this information, a clear and simplified prescription is created for the patient to follow every day (see Fig. 11). We prescribe that struts 1 and 2 be turned in the morning, struts 3 and 4 in the afternoon, and struts 5 and 6 in the evening for a total movement of 1 mm/day. The duration of the adjustment phase depends on the amount of correction needed and is typically between 14 and 28 days. The length of time in the frame is approximately 3 months.

Pain Management

Transdermal wires and pins can be irritating, and we encourage patients to use appropriate oral pain medications. This is especially true during the adjustment period. Once the correction is complete, the frame is no longer moving, and the pain level decreases. Severe or atypical pain merits an evaluated for infection or DVT.

Pin Care

The dressings are removed on postoperative day 2. Nurses teach proper daily pin care consisting of a mixture of half-normal saline and half hydrogen peroxide applied to the pin sites with sterile cotton swabs. Pins and wires are covered with Xeroform dressings at the skin (Fig. 11). Patients are allowed to begin showering on the fourth postoperative day. They are instructed to wash the frame and pin sites with antibacterial soap as an adjuvant form of pin care. Problematic smooth wires can be removed in the office without anesthetic. This is particularly done after the distraction phase or if a wire is painful and infected.

FIGURE 11. Xeroform dressings act as a barrier to bacterial access into the pin sites and keep the skin soft, reducing symptoms of pin irritation.

Rehabilitation

GA Ilizarov stressed the importance of early physical conditioning in conjunction with the application of circular fixators. Early motion increases blood flow to the lower extremity, prevents joint stiffness, and shortens recovery time.[11] In hospital physical therapy assists with weight-bearing as tolerated ambulation and range-of-motion exercises for the knee and ankle joints. Crutches are typically needed for the first 4–6 weeks after surgery. Occupational therapy provides a custom neutral foot splint to prevent equinus posturing during sleep. Patients are encouraged to attend outpatient physical therapy where they continue with their rehabilitation programs.

Frame Removal

Fixators are removed when patients are ambulating without pain or the use of an assistive device and when callus is seen on three cortices around the osteotomy site. This is typically 3 months after the index surgery. We prefer to remove the frames in the operating room. The removal of hydroxyapatite-coated pin can be painful and is best done under sedation. We choose to curette and irrigated all half pin sites in an effort to keep pin tracts clean for possible later arthroplasty. Transfixtion wire sites are not debrided unless there is concern over a specific site. At the time of frame removal, bony union and maturation of the regenerate may be evaluated with a stress test under C-arm fluoroscopy. The struts are removed and the rings manually compressed and distracted, looking for motion at the osteotomy site. A lack of consolidation will require replacement of the struts and prolonging the time in the frame. Once the fixator is removed, patients are placed into a hinged knee brace with 0–90° of motion. They are allowed 50% partial weight-bearing for 2 weeks and then progress to full weight-bearing thereafter.

POSSIBLE CONCERNS AND FUTURE OF TECHNIQUE

The addition of cartilage-sparing and -regenerating procedures to the proximal tibial osteotomy technique may prove to increase the longevity of the procedure. Many authors advocate the routine use of knee arthroscopy with abrasion chondroplasty, microfracture, or subchondral drilling at the time of HTO.[23,29] These procedures are easily performed during arthroscopy and add minimal cost to the surgery. Meniscal transplantation and autogenous chondrocyte implantation are expensive techniques that may prolong the integrity of the knee articular surfaces when combined with tibial realignment osteotomy. Further studies need to be undertaken to determine the efficacy of these combined procedures, guidelines for candidacy, and the cost–benefit relation.

In only a few short years, the TSF computer programming technology has improved dramatically. New software for calculating deformity and mounting parameters using digital radiographs is under development. This could simplify the process even further. The role of computer-aided navigation in tibial osteotomy using the TSF has yet to be realized. Navigation may have a profound impact on the accuracy of deformity correction. This may be most useful in the setting of acute correction where the accuracy of bone cuts is essential. There could be advantages of its use intraoperatively when planning gradual corrections as well. Navigation may also be found to decrease fluoroscopy usage and operative time.

SUMMARY

Proximal tibial osteotomy using the Ilizarov method and the TSF has several advantages over traditional techniques. It is minimally invasive, and there is no internal hardware. There is no need for acute deformity correction, which should be safer in terms of neurovascular complications. Postoperative adjustability allows a very precise correction. Complex deformity and large deformity can be managed as well as simple deformity correction. The TSF in particular is helpful for simultaneous correction of rotation, angulation, and translation in all planes. Whereas the standard osteotomy is below the tubercle, this can be modified to tension the medial and lateral collateral ligaments as needed.[30] The circular frame allows patients to weight-bear as tolerated, having the advantage of diminishing disuse osteopenia, muscle atrophy, and allowing the patient to stand for a bipedal radiograph. Precise analysis of the correction can be done and additional adjustment may be recommended as needed.

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