Arch Orthop Trauma Surg (2002) 122 : 295–298
DOI 10.1007/s00402-001-0370-7

CASE REPORT

S. Robert Rozbruch · David L. Helfet · Arkady Blyakher

Distraction of hypertrophic nonunion of tibia with deformity using Ilizarov/Taylor Spatial Frame

Report of two cases

Received: 14 May 2001 / Published online: 31 January 2002

Abstract Two cases of hypertrophic nonunion of the tibia with deformity for which distraction treatment using an Ilizarov/Taylor Spatial Frame (Smith & Nephew, Memphis, TN) are presented. This frame utilizes a computer program to help plan correction of the deformity.

Keywords Hypertrophic nonunion · Tibia · Ilizarov/Taylor spatial frame · Distraction osteogenesis

Introduction

Complex tibia fractures can result in nonunion. This is often related to the severity of the injury, the presence of infection, and the number of prior surgeries. The nonunion is regularly associated with shortening, deformity, and poor condition of the skin. The deformity is often complex and includes components of translation, angulation, and rotation. Treatment methods have included plating, bone grafting, external fixation, and intramedullary nailing [2, 3, 9].

The Ilizarov method has gained many advocates for the treatment of nonunion over the last two decades, especially for hypertrophic nonunions of the tibia [1, 4, 6, 7, 10, 11]. This approach does not require surgical exposure of the nonunion site nor does it utilize bone grafting. The classic Ilizarov frame has been used to correct all deformities. However, deformity correction of translation and rotation can be complex and cumbersome with such a frame, requiring lengthy frame modifications.

The Taylor Spatial Frame uses the same concepts of distraction osteogenesis as the classic Ilizarov frame. However, it can be used with the help of a computer program to simultaneously correct length and all aspects of deformity including angulation, translation, and rotation. This is accomplished by establishing a "virtual hinge" in space around which all deformity is corrected. Circular rings are connected with six struts, which are gradually adjusted by the patient to correct the entire deformity.

Two clinical cases of patients with hypertrophic nonunion of the tibia with deformity treated using the Ilizarov/Taylor Spatial Frame are presented. This specific approach has not been previously published in the English language orthopedic literature.

S.R. Rozbruch (✉) · D.L. Helfet · A. Blyakher
Limb Lengthening Service, Orthopaedic Trauma Service, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, USA
e-mail: RozbruchSR@hss.edu,
Tel.: +1-212-6061415, Fax: +1-212-7742744

Case reports

Case 1

A 46-year-old male pedestrian was struck by a motor vehicle. He sustained a high-energy closed fracture of his right tibia and fibula. This was treated with open reduction and internal fixation with a plate and screws on the day after the injury. Apparently, there was drainage of purulent material, and plate removal was performed 8 weeks following the initial surgery. This was followed by a 6-week course of intravenous cefazolin. The drainage ceased, but there was increasing deformity and continued pain noted in the right leg. He presented to us 1 year after injury in a short leg cast and with pain and increasing deformity. He was ambulating with two walking canes, and he had localized the pain to the level of the deformity in his leg.

On physical examination, he had a large varus deformity of his right leg (Fig. 1a) with little motion on the nonunion site. Range of motion of his right knee was full extension to 130 deg of flexion. His right ankle motion was from 20 deg of dorsiflexion to 50 deg of plantar flexion. The neurologic and vascular examinations of the right lower extremity were normal. There was a 20 cm healed wound over the proximal lower leg with thin atrophic skin over the nonunion site. Prominence of the nonunion site was noted on the anteromedial surface of the tibia.

Radiographs of the tibia showed a hypertrophic tibia nonunion with the following deformity of the proximal to mid-third of the right tibia: 40 deg of varus, 11 deg of procurvatum, and 14 mm of anterior translation of the distal fragment. Mechanical axis deviation (MAD) [8] was 7.8 cm medial to the center of the knee (Fig. 1b,c). The leg length discrepancy (LLD) was 3.2 cm, with the right leg being shorter. The erythrocyte sedimentation rate was 8, and the indium nuclear scan suggested no infection.

Problem list:

1. Stiff hypertrophic nonunion of right leg following trauma
2. History of infection

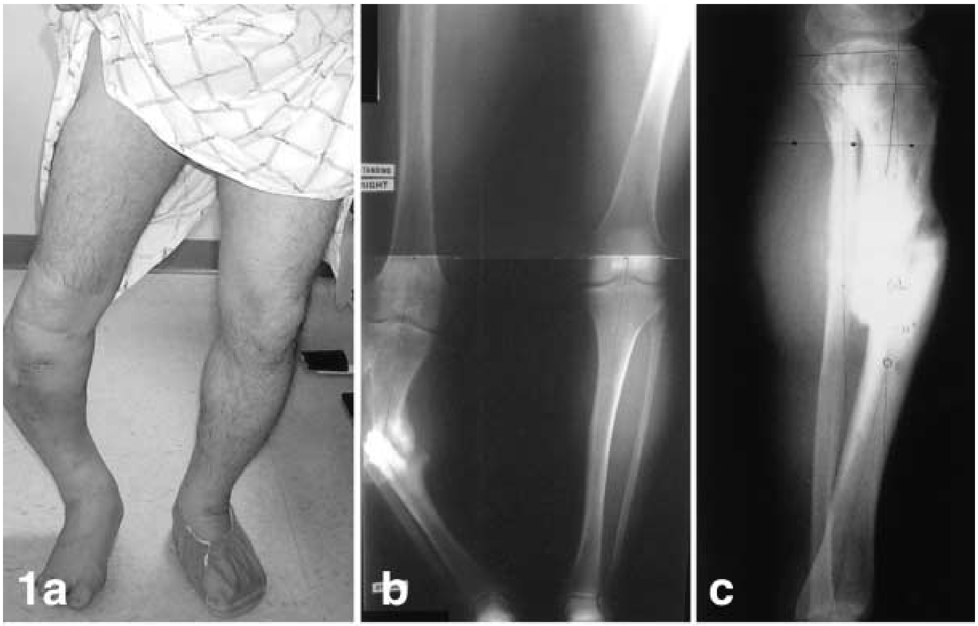

Fig. 1a Frontal view of patient standing showing varus deformity. **b** Preoperative erect leg standing anteroposterior (AP) radiograph showing 40 deg of varus deformity. **c** Preoperative lateral tibia radiograph showing procurvatum and translation deformity

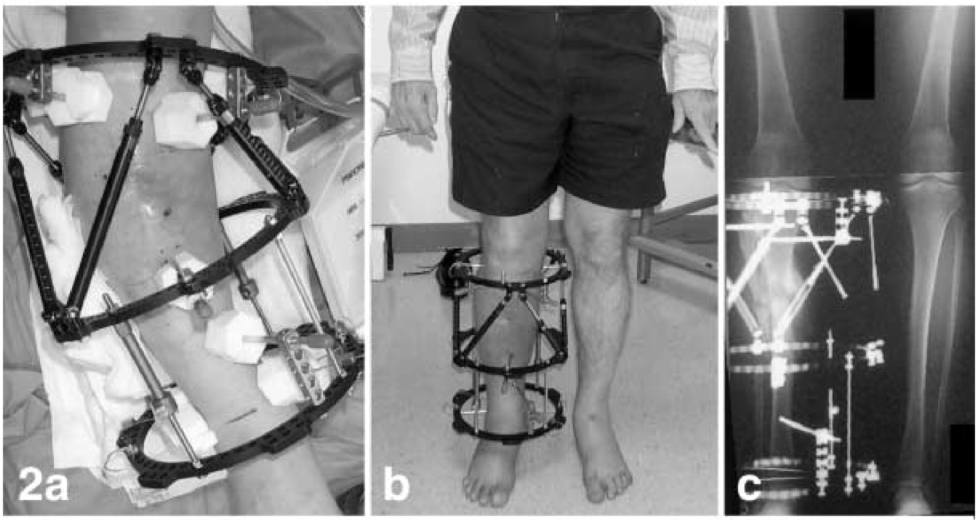

Fig. 2a Immediate postoperative view showing Taylor Spatial Frame (Smith & Nephew, Memphis, TN) applied to leg matching the deformity. **b** Frontal view of patient standing at end of distraction phase showing a neutral frame and a straight leg. **c** Erect leg AP radiograph at end of distraction phase showing correction of deformity

Fig. 3a Front view of patient 1 month after frame removal and 5 months after initiation of treatment. **b** AP radiograph of tibia showing bony union and correction of deformity. **c** Lateral radiograph of tibia showing bony union and correction of deformity

3. Oblique plane deformity with 40 deg varus, 11 deg procurvatum, and anterior translation of the distal fragment
4. 3.2 cm leg length discrepancy
5. Poor quality skin

Treatment plan:

1. Distraction of hypertrophic nonunion without surgical exposure of nonunion and without a need for bone grafting
2. Gradual deformity correction: safe for neurovascular structures
3. Use Ilizarov/Taylor Spatial Frame: gradually correct deformity and shortening
4. Fibula osteotomy

At surgery, an oblique osteotomy of the fibula was performed. The nonunion was found to have 10 deg of motion after the fibula osteotomy. A Taylor Spatial Frame based on the specific deformity parameters and mounting parameters was assembled. The center of rotation and angulation (CORA) [8] was 12 cm distal to the proximal ring, which was designated the reference ring. The three-ring frame was applied to match the deformity of the leg with a combination of 1.8 mm Ilizarov wires and 6 mm hydroxyapatite-coated half-pins (Fig. 2a).

After 2 days, frame adjustments were begun following a 38-day computer-generated schedule resulting in complete correction of the deformity (Fig. 2b,c). At 3.9 months, the frame was removed, and a short leg walking cast was applied. Twenty-seven days later, the cast was removed, and he was able to walk with full weight-bearing without any difficulty.

His leg alignment was normal (Fig. 3a). Ankle range of motion was 15 deg of dorsiflexion to 40 deg of plantar flexion. Knee range of motion was full extension to 135 deg of flexion.

Radiographs showed complete healing of the tibial nonunion and correction of the deformity (Fig. 3b,c). MAD was 0 mm. Medial proximal tibial angle (MPTA) and lateral distal femoral angle (LDFA) were both 87 deg. Posterior proximal tibial angle (PPTA) was 87 deg [8]. LLD after treatment was 0 mm. At the 12-month follow-up, the patient was without pain and had returned to all of his usual activities

Case 2

A 38-year-old man fell off a ladder and sustained a closed fracture of the left proximal tibia with intra-articular extension into the lateral tibial plateau. Open reduction and internal fixation was performed the next day. An electrical bone stimulator was utilized in the postoperative period. He continued to feel pain, and removal of the plate was performed 7 months following injury. He continued to feel pain on weight bearing and presented to us 10 months following injury. He is a non-smoker. There was no history of infection in the leg.

On physical examination, he was noted to have a visible varus deformity of the leg. No mobility was noted at the proximal tibia nonunion. Knee motion was 0–100 deg. Ankle motion ranged from 20 deg dorsiflexion to 50 deg plantar flexion. The thigh-foot axis (TFA) was 15 deg external rotation on the right and neutral on the left side. The neurologic and vascular examinations were normal.

Radiographs showed a hypertrophic nonunion of the proximal tibia metaphysis with a varus deformity. The intra-articular fracture component was healed. MAD was 7.3 cm medial to the midline of the knee. MPTA was 70 deg. PPTA was 70 deg. Analysis of deformity showed 17 deg of varus and 4 deg of procurvatum with the center of rotation and angulation (CORA) to be 5 mm distal to the knee joint line [8]. LLD was 12 mm, with the right leg being shorter.

Problem list:

1. Oblique plane deformity with 17 deg of varus and 4 deg of procurvatum
2. Internal rotation deformity 15 deg
3. Hypertrophic nonunion
4. LLD 12 mm

The deformity parameters were measured off the radiographs and were input into the Taylor Spatial Frame computer program, and strut settings to match the deformity were established. At surgery, a fibula osteotomy was performed. The tibia nonunion was noted to have little mobility after the fibula osteotomy. The frame was assembled to match the deformity of the leg. It was then fixed to the leg using Ilizarov wires and half-pins. Frame adjustments were commenced on the first day after surgery. Correction of the deformity was accomplished in 30 days. MPTA and LDFA were 87 deg. MAD was 0 mm. PPTA was 87 deg. LLD was 6 mm. Full weight-bearing was allowed as tolerated. The frame was removed 4 months following its application, and a hinged knee brace was applied. Over the next few weeks, the brace was removed. The latest follow-up was conducted at 8 months following frame removal and 12 months following initial treatment. The bone had united, and there was no loss of deformity correction. The initial presenting tibial pain with weight-bearing had been eliminated. However, he still had knee pain and signs of early post-traumatic arthritis of the lateral joint compartment of the knee. Knee range of motion is 0–115 deg. Ankle range of motion is 10 deg dorsiflexion to 40 deg plantar flexion.

Discussion

The Ilizarov method has proven effective in the treatment of patients with complex tibia nonunions with deformity and shortening.

Ilizarov [4, 5] also introduced a new approach for treating hypertrophic nonunions using an external fixator to stimulate osteogenesis by distraction at the nonunion site. There have been 5 reports in the English language orthopedic literature in which distraction osteogenesis has been used successfully to treat hypertrophic nonunions with deformity following trauma [1, 6, 7, 10, 11].

In the situation of a hypertrophic nonunion, instability is the primary problem, whereas the biological capacity for healing does not play a major role. The fibrocartilaginous tissue of a hypertrophic nonunion has osteogenic potential, which can be realized once torsional and angular instabilities are eliminated. Contrary to popular belief, compression is not the only force required for healing. When the torsion and shear forces are eliminated, distraction or compression forces applied to the site of the nonunion leads to new bone formation and healing of the nonunion. During this process, both limb deformity and shortening can be corrected with the application of an opening wedge correction [1, 4, 6, 7, 10, 11]. This approach does not require exposure or bone grafting of the nonunion site, minimizing the risk of wound complications, deep infection, and eliminating bone graft site morbidity. Also, the ability to perform a gradual correction of the deformity minimizes the risk of damage to nerves and vascular structures from overstretching on the concave side of the deformity. The Taylor Spatial Frame computer program helps calculate an appropriate correction schedule so that the “structure at risk” is not stretched more than 1 mm per day.

The Taylor Spatial Frame is an evolution of the classic Ilizarov frame. It uses mathematics and a computer program to help build a frame to match the deformity. Gradual adjustment of the connecting struts leads to complete correction of deformity. Our clinical report has confirmed this to be a practical and successful treatment.

References

1. Catagni MA, Guerreschi F, Holman JA, Cattaneo R (1994) Distraction osteogenesis in the treatment of stiff hypertrophic nonunions using the Ilizarov apparatus. Clin Orthop 301: 159–163
2. Green SA, Garland DE, Moore TJ, et al (1984) External fixation for the uninfected angulated nonunion of the tibia. Clin Orthop 190: 204–211
3. Helfet DL, Jupiter JB, Gasser S (1992) Indirect reduction and tension-band plating of tibial non-union with deformity. J Bone Joint Surg Am 74: 1286–1297
4. Ilizarov GA (1992) Pseudoarthrosis and defects of long tubular bones. In: Ilizarov GA (ed) Transosseous ostesynthesis: theoretical and clinical aspects of regeneration and growth of tissue. Springer, Berlin Heidelberg New York, pp 453–494
5. Ilizarov GA (1989) The tension-stress effect on the genesis and growth of tissues. Part 1. The influence of stability of fixation and soft-tissue preservation. Clin Orthop 238: 249–281
6. Paley D, Catagni MA, Argnani F, et al (1989) Ilizarov treatment of tibial nonunions with bone loss. Clin Orthop 241: 146–165
7. Paley D, Chaudray M, Pirone AM, et al (1990) Treatment of malunions and mal-nonunions of the femur and tibia by detailed preoperative planning and Ilizarov techniques. Orthop Clin North Am 21: 667–691
8. Paley D, Herzenberg JE, Tetsworth K, et al (1994) Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am 25: 425–465
9. Rosen H (1979) Compression treatment of long bone pseudoarthroses. Clin Orthop 138: 154–166
10. Rozbruch SR, Herzenberg JE, Tetsworth K, et al (2002) Distraction osteogenesis for nonunion after high tibial osteotomy. Clin Orthop 394:227–235
11. Saleh M, Royston S (1996) Management of nonunion of fractures by distraction with correction of angulation and shortening. J Bone Joint Surg Br 78: 105–109