Case 22: Bone Transport to a Knee Fusion and Secondary Intramedullary Nailing s/p Gunshot Wound

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Abstract

A 33 year old woman sustained a close range shotgun injury to her left proximal tibia. This resulted in a large medial wound with significant bone loss without neurovascular injury. She was treated in a delayed fashion with an open reduction and internal fixation using medial and lateral locking plates. A severe infection developed requiring plate removal and extensive debridement resulting in an 11 cm bone defect. A complex circular frame was placed and the bone loss was reconstructed with bone transport using both femoral and tibial corticotomies to a knee fusion. Following docking and bone grafting, the frame was removed with immediate conversion to a customized intramedullary fusion nail. The patient resolved the infection, healed the regenerate segments and the knee fusion, and is currently ambulating with equal leg lengths without assistive devices.

1 Brief Clinical History

A 33 year old woman sustained a close range shotgun injury to her left proximal tibia (Fig. 1). She was initially treated with debridement and placement of a spanning unilateral external fixator with a vacuum assisted closure over antibiotic beads (Fig. 2). When the wound was clean, she underwent an open reduction and internal fixation of her proximal tibia with a locked lateral plate, and flap coverage (Fig. 3a–c). This became infected requiring complete hardware removal and extensive bone debridement, resulting in an 11 cm total bone loss (Fig. 4). Limb reconstruction was managed with bone transport to a knee fusion with tibial and femoral corticotomies (Figs. 5 and 6). Docking site alignment and knee fusion position was controlled by Taylor spatial frame at the center of the Ilizarov frame. Following docking and bone grafting, the frame was converted immediately to a customized locked

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Fig. 1 3D CT scans showing the extent of injury to the proximal tibial articular surface and metaphysis

Fig. 2 AP (*left*) and lateral (*right*) images after initial debridement of injury with antibiotics beads in place

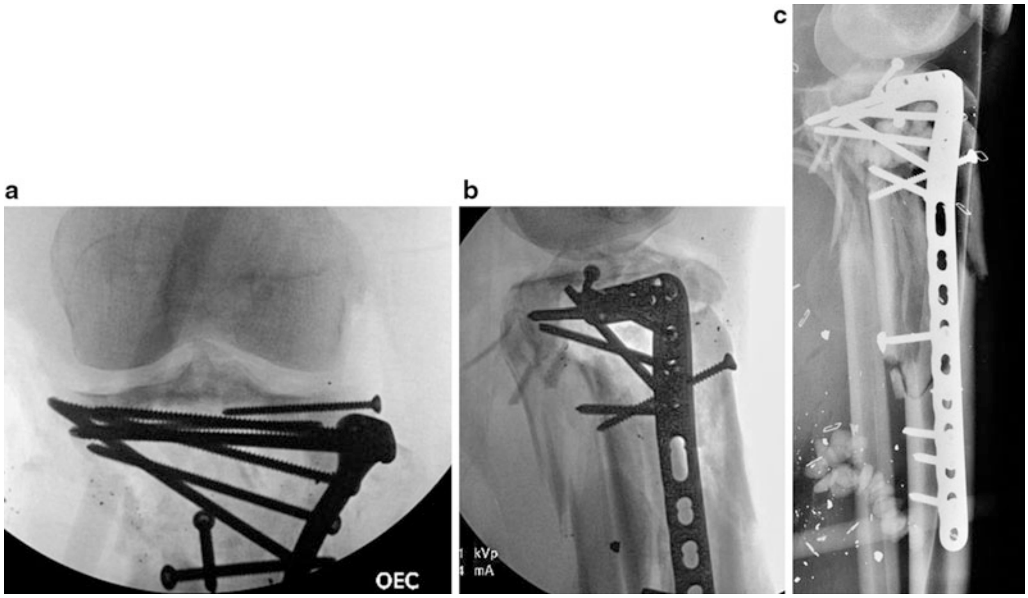

Fig. 3 (**a–c**) Intra-operative and post-operative radiographs following open reduction and internal fixation. AP (**a**), Lateral (**b**, **c**)

intramedullary fusion nail to allow relatively early frame removal (Figs. 8 and 9b–c). Reaming for the intramedullary nail was by a RIA (reamer irrigator aspirator) to minimize contamination of the medullary canal (Fig. 9a).

2 Preoperative Clinical Photos and Radiographs

See Figs. 1, 2, 3, and 4.

3 Preoperative Problem List

1. Deep infection (enterobacter and proteus).
2. Loss of extensor mechanism.
3. 11 cm bone loss.
4. Insulin dependent diabetes mellitus.
5. Medial flap and skin graft.

4 Treatment Strategy

We discussed the above knee amputation with the patient but she wished to proceed with limb salvage. The wound was sterilized with multiple debridements, essentially removing the entire proximal tibia and placing of antibiotic beads (vancomycin/tobramycin) in the defect. Bifocal bone transport was selected to shorten the treatment time. The frame was constructed with a transport segment in the distal femur and the distal tibia. Standard Ilizarov "clickers" were

Fig. 4 Radiograph following extensive debridement of all infected hardware, bone and extensor mechanism. Bone loss is ~11 cm

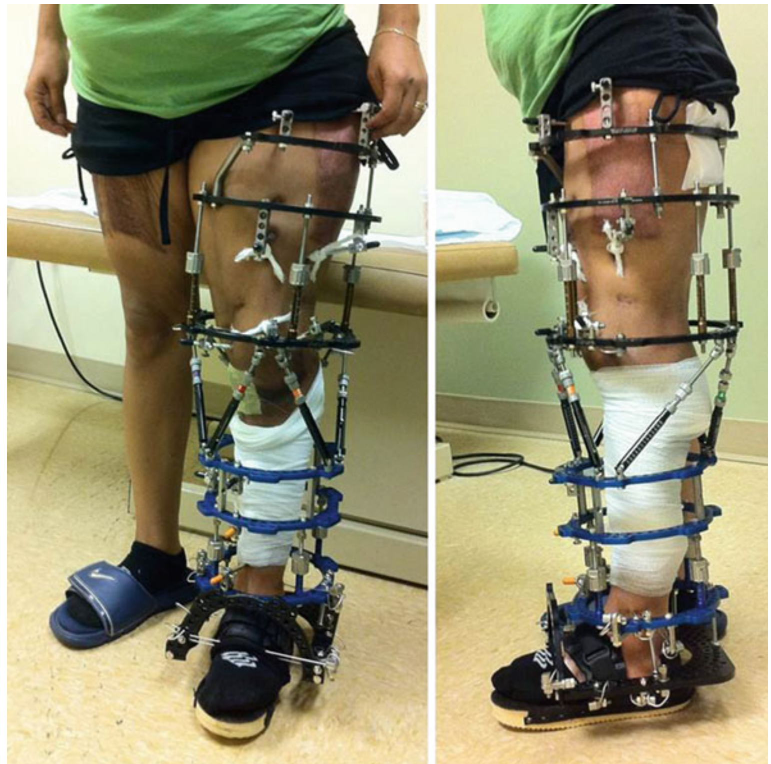

Fig. 5 Frontal (*left*) and lateral (*right*) clinical photographs showing frame construction. Note the use of standard "clickers" for lengthening and spatial frame struts in the middle of the frame for alignment

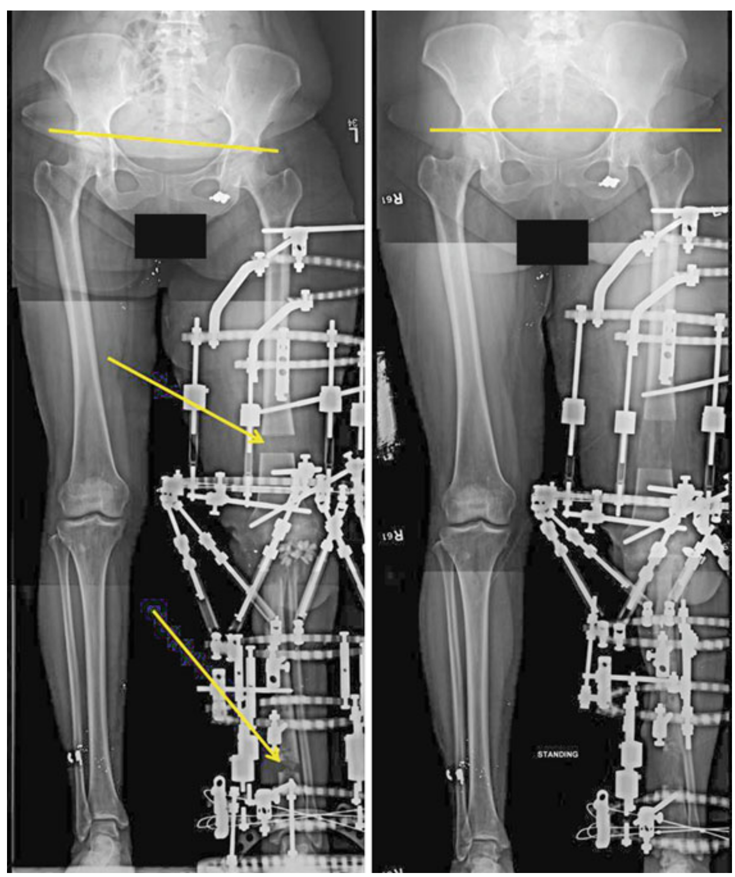

Fig. 6 Standing frontal alignment films showing frame construction and location of femoral and tibial regenerate bone (*arrows*) at the middle (*left*) and end of treatment (*right*)

used at the transport segments and the rings at the distal femur and proximal tibial segments were joined using spatial frame struts to allow control of the docking site and the overall knee fusion position (Figs. 5 and 6). This was important since we planned on early conversion to a locked intramedullary fusion nail. Both corticotomies were by the multiple drill hole/osteotome technique. All half pins were hydroxyapatite coated 6 mm stainless steel. The foot was incorporated in the frame to prevent equinus secondary to retrograde tibial transport and leg lengthening. The patient ambulated with a custom footplate attachment (Fig. 5). Tibial transport was at 0.5 mm per day in two increments and femoral transport was at 1 mm per day in four increments. We planned to make the femoral regenerate (7 cm) about twice as long as the tibial regenerate (4 cm) to create nearly equal treatment times. The Taylor Spatial Frame prescription was planned to align the femoral/tibial docking segments and create an alignment that would allow an intramedullary fusion nail to be passed. After docking was achieved, the knee fusion/docking site was bone grafted with autogenous graft from the contra-lateral femur using the reamer irrigator aspirator technique. Following reestablishment of leg length and recovery from bone grafting, a long intramedullary fusion nail (13 mm diameter: Smith and Nephew) with a piriformis starting location was selected and customized by predrilling 2–3 mm holes in a location that would allow a locking screw (2.7 mm) to be placed into both the distal femur segment and proximal tibial segments to hold the relative positions of these segments during regenerate consolidation (Fig. 8). At the time of conversion to the intramedullary fusion nail, the patient was given broad spectrum antibiotics and the frame was thoroughly prepped into the field. All transfixation wires were removed and all half pins were pulled back to a unicortical position to maintain segment alignment as the custom IM nail was passed (Fig. 9b–c). Reaming for the IM nail was by the reamer irrigator aspirator (RIA – Synthes USA) to remove the reaming debris from the medullary canal and minimize the risk of infection (Fig. 9a).

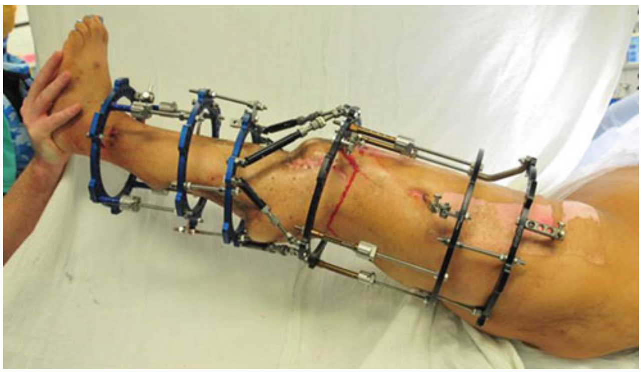

Fig. 7 Appearance of the leg and frame at the time of conversion to intramedullary fusion nail

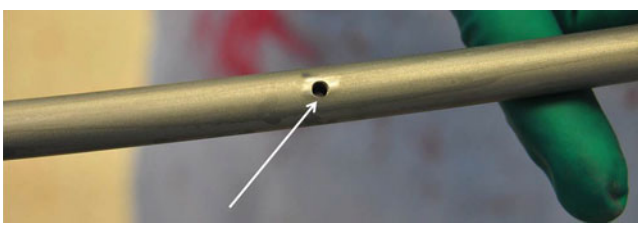

Fig. 8 Appearance of the 3 mm hole (*arrow*) to allow placement of a 2.7 locking screw at two locations in the nail to maintain compression of the knee fusion after IM nailing

Fig. 9 (**a**–**c**) Intra-operative radiographs of placement of the intramedullary nail. (**a**) Reamer irrigator aspirator (RIA – Synthes USA) to prepare canal (**b**) Passage of the nail with the external fixation half pins in the unicortical position (**c**) 2.7 locking screw in place in the distal femur segment

Fig. 10 Final alignment of the nail following removal of the external fixator

5 Basic Principles

1. Thorough wound debridement and treatment of infection (antibiotic beads and IV antibiotics).
2. Stable frame on both tibial and femoral segments.
3. Alignment of tibial and femoral segments with Taylor spatial frame.
4. Atraumatic corticotomies, 10-day latency period.
5. Differential distraction in tibia (0.5 mm/day) and femur (1.0 mm/day).
6. Incorporation of foot into frame.
7. Bone grafting of docking site.
8. Optimize host factors: glucose control, smoking cessation, Vitamin D levels.

6 Images During Treatment

See Figs. 5, 6, 7, 8, 9, and 10.

7 Technical Pearls

1. This extensive frame is difficult for the patient to manage and all efforts should be made to create a stable comfortable frame to allow weight bearing and promote regenerate consolidation. Incorporation of the foot is mandatory to control equinus during retrograde tibial transport.

Fig. 11 (**a**, **b**) Lateral (**a**) and AP (**b**) Radiographic appearance of the extremity 1 year from the date of injury. The patient underwent additional bone grafting at the fusion site to obtain final union

Fig. 12 (**a**, **b**) Lateral and medial views of the leg 1 year from the date of injury at the time of additional bone grafting to docking site. *Top* (lateral), *bottom* (medial)

2. Since early conversion to IM nailing was planned, the use of HA coated pins minimized the complications with pin infections that may contribute to infection following nail insertion and frame removal.
3. Regenerate formation in the distal tibia is generally less robust than in the distal femur, and therefore a slower rate of distraction is required in the distal tibia. (0.5–0.75 mm/day).
4. The use of the spatial frame to control alignment of the fusion site made subsequent nailing much easier since we could assure alignment of the medullary canals of the tibia and femur.
5. Custom locking holes in the fusion nail allowed continued compression of the fusion site after frame removal.
6. Preparation of the canal with the reamer irrigator aspirator *may* reduce the incidence of infection after this relatively risky immediate conversion from frame to nail.

8 Outcome Clinical Photos and Radiographs

See Figs. 11 and 12.

9 Avoiding and Managing Problems

Perhaps the biggest risk with this entire procedure is the immediate conversion to IM nailing, while the fixator is still in place. Given the complexity of the construct, it is not practical in this case to remove the frame and provide a "frame free" interval prior to nailing. Use of HA coated pins, no history of pin tract infections, use of the RIA for canal preparation, and broad spectrum perioperative antibiotics all help reduce the chance of a secondary infection.

10 Cross-References

▶ Case 13: Trifocal Tandem Transport for Proximal Tibial Bone Defect and Fracture Dislocation of the Knee
▶ Case 40: Acute Shortening and Arthrodesis Technique in Severe Irreparable Tibial Pilon Fracture

References and Suggested Reading

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