An Indirect Reduction Technique for Percutaneous Fixation of Calcaneus Fractures

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Abstract

We describe a positioning and indirect reduction method that allows for earlier fixation of some displaced calcaneus fractures. Minimally invasive surgery with this technique can provide good results in high-risk patients while minimizing soft-tissue complications.

Calcaneus fractures are often complicated by severe soft-tissue compromise, with poor results noted in patients with impaired biological activity (those with diabetes or peripheral vascular disease; smokers).[1-5] The standard for fixation of these fractures is open reduction and internal fixation through an extensile approach. However, soft-tissue complications continue to pose a significant risk to patients. Percutaneous fixation of these fractures through indirect reduction reduces the risk associated with wound complications, in part because of earlier fixation.[6] Relative guidelines for closed reduction and percutaneous fixation of calcaneus fractures have been established, and early published results continue to be promising.[6,7]

In this article, we describe a simplified method of indirect reduction and percutaneous fixation of calcaneus fractures. This method is designed to enhance the speed, ease, and accuracy of the procedure while minimizing risks to the injured soft tissues. The patient provided written informed consent for print and electronic publication of his case report.

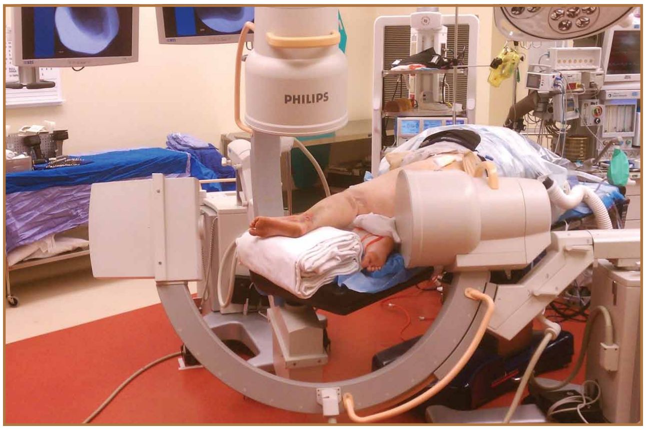
Operative Procedure

The patient is positioned in the lateral decubitus position with a bean bag and an axillary roll (**Figure 1**). This lateral position minimizes the external rotation deformity of the involved limb and thereby allows for enhanced imaging. The opposite extremity is padded with blankets to build a square base on which the involved limb can rest during the case. The padded blanket "table" does not obscure the anatomical signature on intraoperative fluoroscopy and allows a wide, stable field on which the operative extremity can rest.

The lateral position also facilitates strategic placement of 2 image intensifiers that maximize the workspace, making it comfortable and convenient for the surgeon. The horizontal image intensifier obtains a Harris axial view of the extremity and is canted to allow the other intensifier to be positioned for a lateral view (**Figures 2A, 2B**). Both the Harris axial view and the lateral view are perfected before sterile preparation of the limb. Operative time is reduced by preparing the extremity and draping it with the horizontal intensifier, focused on the axial view, left in position. The image intensifier for the lateral view is quickly and easily repositioned after surgical draping.

Indirect reduction of the calcaneus begins with application of an external fixator to the involved extremity. Two 5.0-mm Schanz pins are placed on the medial and lateral aspects of the tibia after predrilling pilot holes with a 3.5-mm bit. Careful surgical technique and use of soft-tissue protectors are recommended when placing the lateral Schanz pin so as to protect the peroneal nerve as it travels through the anterior compartment distally. This nerve is particularly at risk 7 to

Figure 1. Preoperative positioning of patient for percutaneous fixation. Bump of operating room blankets is taped below involved limb to create flat, stable surface for surgery. Horizontal image intensifier is placed for Harris axial view, vertical image intensifier for lateral view. This positioning provides ample workspace with clear view of operative site.



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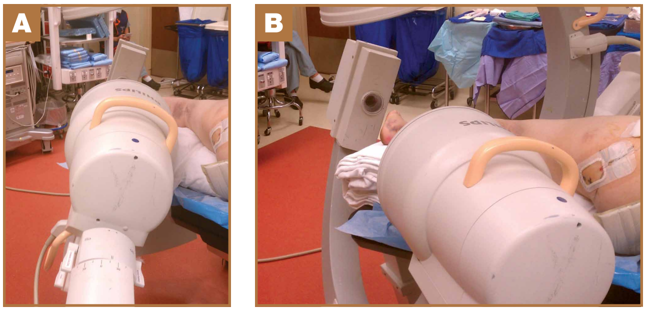

Figure 2. (A) Axial image intensifier is canted slightly to allow room for (B) second, vertically oriented image intensifier to be positioned for lateral image.

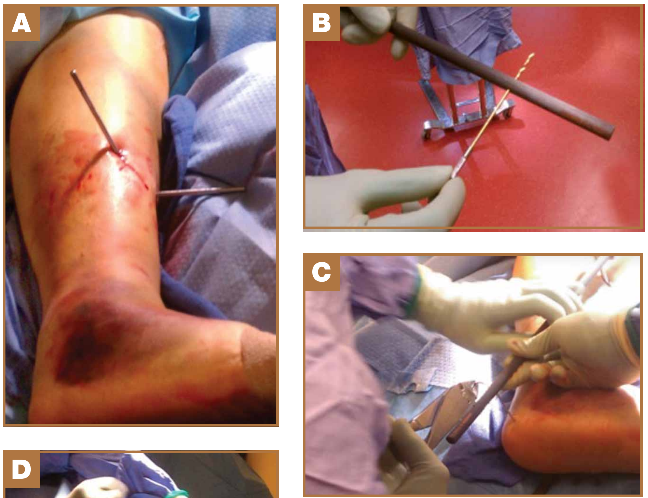

Figure 3. Lateral views. (A) In setup for distracting external fixator frame, two 5.0-mm Schanz pins are placed in tibia, and 2.0-mm stainless steel wire is passed through posteroinferior portion of posterior tuberosity. (B) Shows 2-mm stainless steel wire threaded through 11-mm diameter carbon fiber rod. (C) The 2.0-mm wire is passed through the posteroinferior portion of posterior tuberosity. (D) Second rod is attached to distal-most aspect of frame to increase stability.

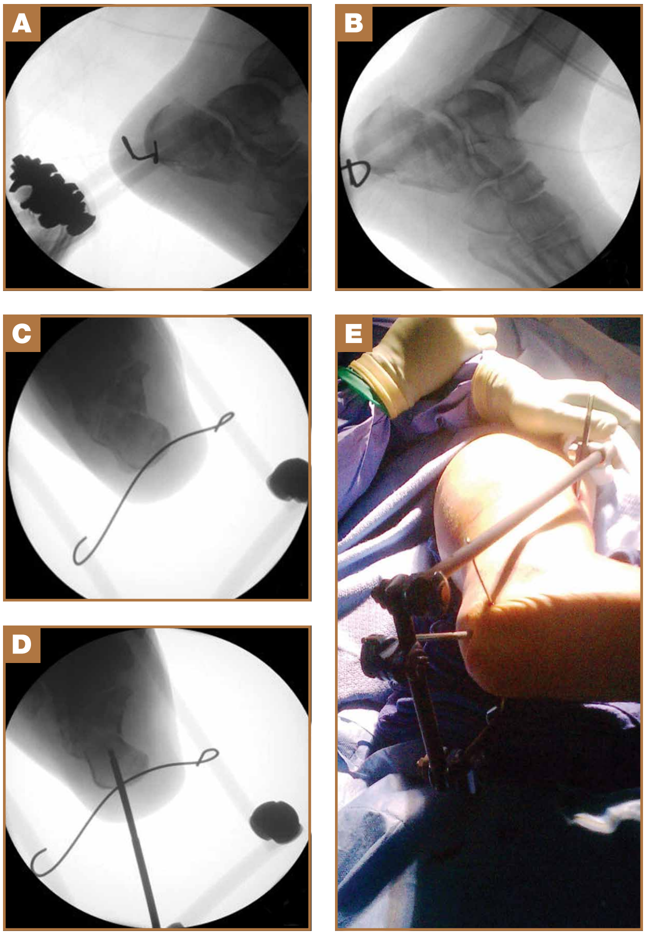

Figure 4. (A) Lateral, intraoperative, fluoroscopic image showing calcaneus prior to distraction. (B) Lateral view, traction is applied and distraction restoration of calcaneal height is demonstrated. (C) Axial view, heel varus partially corrected with distraction. (D) Remaining hindfoot varus is reduced with 5-mm Schanz pin attached to external fixator frame and used as a joystick. (E) Intraoperative photograph showing how joystick is used to maintain reduced position, freeing up operator's hands to proceed with case.

12 cm proximal to the distal tibial articular surface.

With fluoroscopic guidance, a 2.0-mm stainless steel wire is passed lateral to medial through the distal and most posterior aspect of the calcaneal tuberosity fragment. The lateral view usually confirms entry and the starting position for the wire, and the axial view confirms wire trajectory and adequate purchase in the tuberosity fragment. For particularly comminuted fractures, multiple wires can be passed to enhance fixation and control of this key fragment.

Biplanar distractors (Synthes, Paoli, Pennsylvania) are then attached to the 5.0-mm Schanz pins. These distractors fit over 11-mm-diameter carbon fiber rods, which are found in most large external fixator sets. These carbon fiber rods range in length from 240 to 400 mm, which provides for flexibility in dealing with variable patient anatomy. A 2.5-mm bit is used to drill a hole through the carbon fiber rod on a back table to allow attachment of the 2.0-mm reduction wire to our external fixator, thereby creating a 2-point distraction frame. The ends of the 2.0-mm wire passed through the tuberosity are threaded through the holes in the carbon fiber rod and then bent to complete our distraction frame. Another carbon fiber bar is attached at the base of the construct to enhance the overall stability of the setup to distraction forces during reduction (**Figures 3A-3D**).

The 2-point traction applied through the distractors allows for correction of shortening and heel varus. A third 5.0-mm

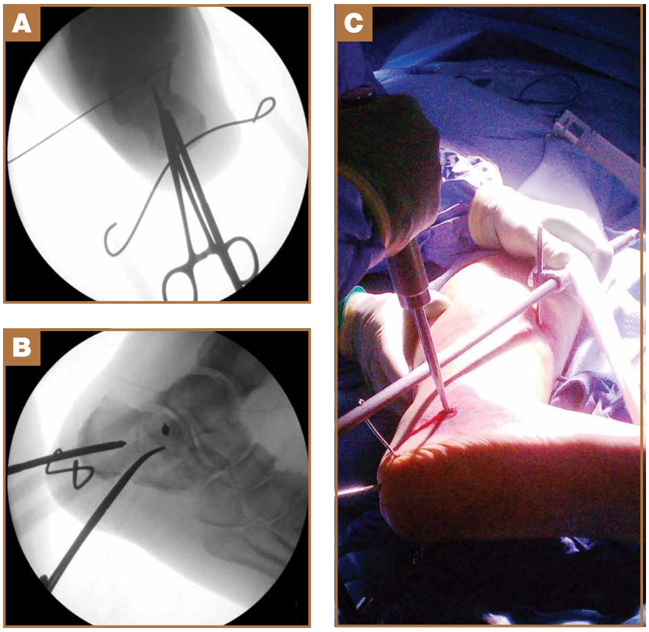

Figure 5. (A) Axial view of percutaneous reduction and elevation of depressed posterior facet with small Cobb elevator and hemostat. (B) Lateral view after reduction, fixation is achieved with a 4-mm cannulated screw from lateral to medial to achieve purchase in sustentaculum tali. (C) Intraoperative photograph, frame allows placement of elevators and reduction devices in several positions.

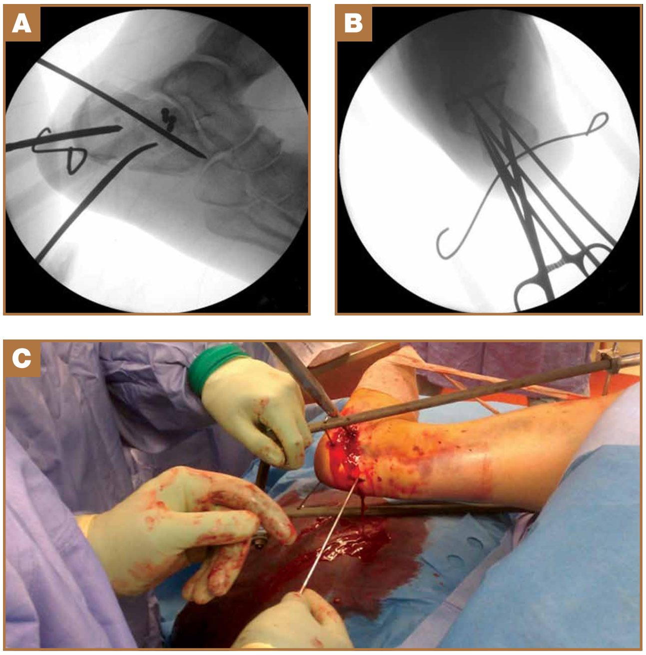

Figure 6. (A) Lateral and (B) axial fluoroscopic views of two 7.3-mm cannulated screws placed in medial and lateral columns of calcaneus. Simultaneous imaging (2 image intensifiers for lateral and axial views) facilitates placement. Dorsal-to-plantar trajectory purchases anterior calcaneus and helps buttress posterior facet. (C) Intraoperative photograph showing distracting external fixator providing ample workspace for placement of screws and reduction devices during procedure.

Schanz pin is placed in the posterior tuberosity for use as a joystick to correct any remaining hindfoot varus. As more traction is placed through the distractors, the inherent elasticity of the tissues decreases, reducing the ability to adjust hindfoot varus with the joystick. The joystick can then be attached to the carbon fiber rods of the external fixator frame to maintain the reduced position while fixation is obtained (**Figures 4A-4E**).

After restoration of heel height and correction of hindfoot varus, attention is then focused on reducing the posterior facet. The position of the distracting external fixator allows for indirect reduction with pins, elevators, and small bone tamps in key areas, thereby sparing the soft-tissue envelope. Small stab incisions are made laterally and on the plantar aspect of the foot to accommodate these reduction devices. After reduction, 3.5- or 4.0-mm cannulated lag screws are placed across the posterior facet fracture lines, lateral to medial. These screws are directed into the intact sustentaculum for best purchase. The image intensifiers quickly confirm placement in the lateral and Harris axial projections. Two 3.5-mm cortical screws can also be used, as some surgeons prefer a solid, 2.5-mm drill bit for improved tactile feedback when confirming placement of screws into solid bone (**Figures 5A-5C**).

Next, two 7.3-mm cannulated screws are placed in the medial and lateral columns of the calcaneus from the large posterior tuberosity fragment into the anterior process. The screws follow a slightly dorsal-to-plantar trajectory to maximize purchase and resist proximal migration of the tuberosity by the Achilles tendon (**Figures 6A-6C**). Additional cannulated screws can be placed in the 5.0-mm joystick Schanz pin hole after its removal, or across secondary fracture lines as needed. Calcium phosphate cement is placed in the bone void after disimpaction of the posterior facet. Again, care must be taken to avoid extravasation of the cement into the soft tissues medially.

The small stab incisions are closed with a 2.0-mm nylon suture, and the extremity is splinted in a short-leg Jones dressing. At this time, any fracture blisters are addressed with deroofing and placement of dry, nonadherent dressing. Patients are kept non–weight-bearing for 8 to 10 weeks and are advanced to full weight-bearing after 3 months.

Case Report

A 75-year-old man, who had diabetes and smoked, sustained a Sanders II calcaneus fracture after a fall. He had a large medial dermal contusion, severe soft-tissue swelling, and multiple fracture blisters. Early dermal necrosis was visualized because of the pressure of the widely displaced sustentaculum tali on the medial aspect of the foot. The patient's age and medical comorbidities put him in a high-risk category for fixation by a formal open approach. **Figures 7 and 8** show his postoperative radiographs. Closed reduction and percutaneous fixation with our technique was performed within 12 hours of injury to reduce pressure on the skin from displaced fracture fragments (**Figures 8A, 8B**). The surgical wounds healed quickly, without issue, but early dermal necrosis and loss of skin on the medial foot occurred, as expected. **Figures 9A-9D** show the progression of the medial-side wound over 4 weeks; restoration of the patient's normal anatomy allowed for uncomplicated soft-tissue healing of the medial pressure sore.

Figure 7. Preoperative (A) lateral and (B) axial radiographs of calcaneus fracture. Postoperative (C) lateral and (D) axial radiographs after closed reduction and percutaneous fixation.

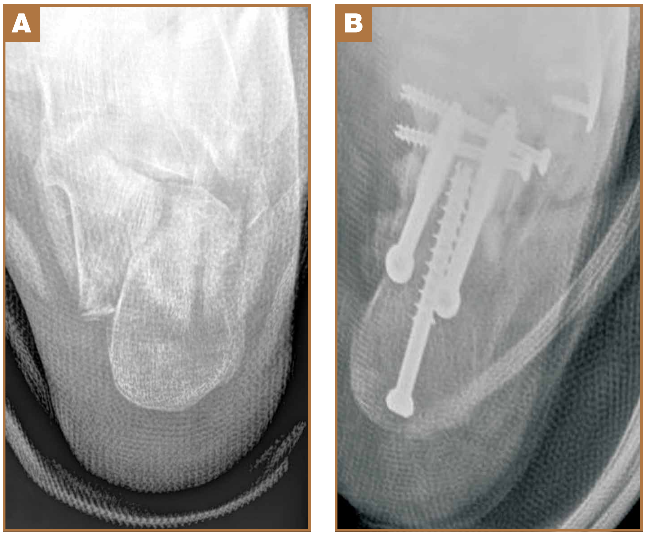

Figure 8. (A) Preoperative and (B) postoperative radiographs of patient with diabetes show reduction of widely displaced calcaneus fracture and hindfoot varus deformity.

Discussion

The indirect reduction technique of percutaneous fixation of calcaneus fractures has several key elements, the most important being lateral position of the patient, use of 2 image intensifiers, and use of 2-point distracting external fixator for reduction. The result is a hands-free reduction technique that maximizes fluoroscopic imaging while providing adequate physician workspace.

Patient positioning has varied from prone to lateral among reported techniques. Prone positioning may be advantageous in treating bilateral injuries simultaneously. Photographs of prone positioning (eg, **Figure 10**) illustrate 2 problems—

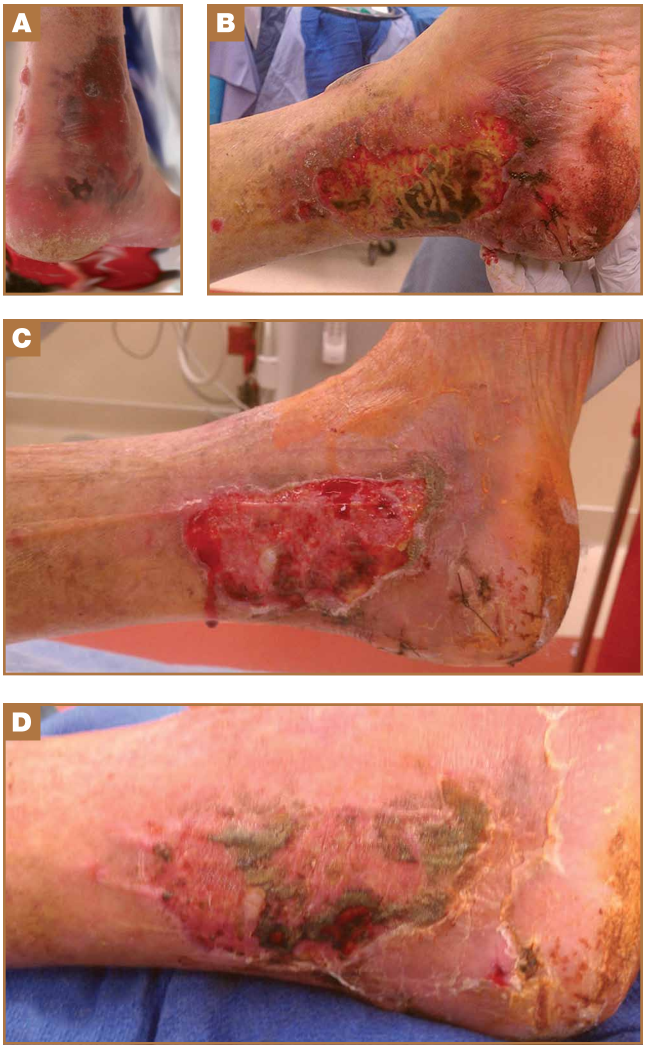

Figure 9. Progression of wound (medial-side partial dermal necrosis from pressure of widened, fractured calcaneus) from time of injury until resolution at 4 weeks. (A) Axial photograph at 1 week, (B) lateral view at 2 weeks, (C) lateral view at 3 weeks, and (D) resolution at 4 weeks. Early restoration of anatomy by surgical intervention with this technique was crucial in avoiding soft-tissue complications.

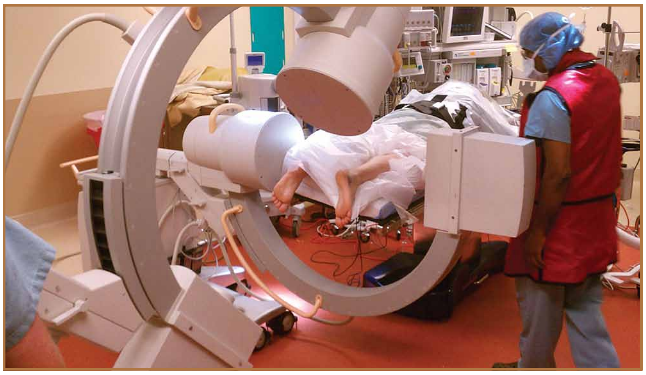

Figure 10. Prone position limits physician workspace. In addition, involved limb is externally rotated in prone position, making accurate lateral imaging more difficult.

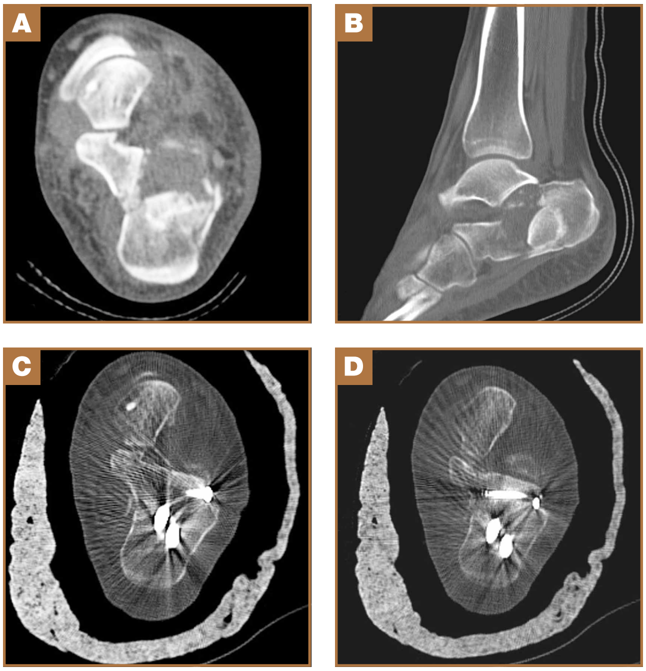

Figure 11. (A) Preoperative axial-view and (B) lateral-view computed tomography scans show displaced 2-part calcaneus fracture. (C,D) Two axial-view postoperative scans show near anatomical reduction of posterior facet.

limited physician workspace, and limb external rotation deformity complicating imaging.[8] One advantage of lateral positioning is ease of correcting the external deformity to minimize its impact on imaging.[9] The flat, padded blanket bump provides a large surface area for extremity placement, as needed for imaging or reduction, and does not obscure bony signature during intraoperative fluoroscopy.

Other techniques have used a single image intensifier during this procedure.[7-12] Having to move the intensifier from an axial view to a lateral view can be time-consuming, and frustrating, as often the new images do not resemble the earlier ones. In our experience, using 2 intensifiers not only speeds up the procedure but also may enhance the accuracy and consistency of the images. Image consistency helps the surgeon appreciate subtle signature changes in radiographic anatomy during reduction, and this information may increase the overall accuracy of reduction.

Closed reduction with percutaneous Kirschner wire (K-wire) fixation has also been used to treat calcaneus fractures.[11,12] Complications of K-wire use include implant migration, wire breakage, and a 7% pin infection rate.[12] K-wires typically are left implanted for 8 to 10 weeks, while the fracture is uniting. Use of cannulated screws can help prevent these complications, as the implants are completely internal and may be less irritating to patients. In cases of poor bone purchase, which typically is found along fracture lines in the anterior process of the calcaneus, additional screw purchase can be gained with judicious use of calcium phosphate cement. Transfixation K-wires placed across the calcaneocuboid joint or subtalar joint for the sake of additional bone purchase are usually not recommended, as they can limit postoperative rehabilitation. There is also the potential for breakage with noncompliant patients.

The configuration of 6.5-mm cannulated screws (from posterior process to anterior process) and a 4.0-mm rafting screw (aimed plantar to dorsal, toward the posterior facet) was biomechanically tested and analyzed in a cadaveric model.[13] Mean load to failure and construct stiffness did not differ significantly between the cannulated screw model and laterally based locked plating. Failure in the cannulated screw model was found most commonly with pullout of the 6.5-mm cannulated screws from the anterior process.[13] Again, in areas of comminuted fractures of the anterior process, calcium phosphate cement can be used to increase screw purchase and fixation, but this remains a potential limitation of the technique. Extravasation of the cement into the soft tissues should be avoided.

The distracting external fixator frame offers several key advantages over other types of indirect reduction constructs. First and foremost, its strategic placement away from the operative field provides completely unobscured fluoroscopic imaging of the complex anatomy. In other published case series, 3-point traction was created with small custom distractors. The proximity of radiodense objects to imaging obstructs visualization, making assessment of reduction difficult.[8,10] Second, the 2.0-mm stainless steel reduction wire is also ideal for this purpose, as it has a small fluoroscopic presence and minimizes soft-tissue disruption. At the end of the procedure, wire removal leaves a small poke hole that need not be sutured for closure. A third advantage is that the overall shape of the distracting external fixator expedites convenient placement of pins, elevators, and small bone tamps for reduction. These pins can be left in place and attached to our external fixator to eliminate the burden of holding them in place until the procedure is completed. This hands-free technique can shorten the procedure and reduce the surgeon's radiation exposure.

The quality of reduction across the posterior facet remains a major concern surrounding use of indirect reduction techniques in treating these fractures. We routinely obtain preoperative and postoperative computed tomography (CT) scans (**Figures 11A-11D**) of an injured calcaneus to assess posterior facet reduction. In our experience, this technique is best suited for extra-articular fractures and simple 2-part intra-articular fractures, as demonstrated by postreduction CT. In more complex fractures in which unacceptable reduction of the posterior facet is found on postoperative CT, an open reduction through the sinus tarsi approach is performed, usually within 2 to 3 weeks. Cannulated screws that would potentially block reduction during the revision procedure are easily removed or repositioned at that time.

The described method of positioning and indirect reduction allows for earlier reduction of displaced calcaneus fractures. For best results, this technique should be performed within 7 days of injury, when indirect reduction techniques likely are most effective.

Novel features of this technique include lateral positioning of the patient, use of a 2-point distraction external fixator frame, and use of 2 image intensifiers. The advantages of this approach are that it facilitates hands-free maintenance of reduction and provides unobscured fluoroscopic imaging of the complex anatomy while maximizing the workspace. As the indications for percutaneous calcaneus surgery continue to expand, minimally invasive techniques can provide good results in even high-risk patients—the elderly, smokers, and patients with diabetes or open fractures—while reducing soft-tissue complications.

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References

1. Buckley R, Tough S, McCormack R, et al. Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial. *J Bone Joint Surg Am.* 2002;84(10):1733-1744.
2. Al-Mudhaffar M, Prasad CV, Mofidi A. Wound complications following operative fixation of calcaneal fractures. *Injury.* 2000;31(6):461-464.
3. Shuler FD, Conti SF, Gruen GS, Abidi NA. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures: does correction of Bohler's angle alter outcomes? *Orthop Clin North Am.* 2001;32(1):187-192.
4. Assous M, Bharma MS. Should os calcis fractures in smokers be fixed? A review of 40 patients. *Injury*. 2001;32(8):631-632.
5. Folk JW, Starr AJ, Early JS. Early wound complications of operative treatment of calcaneus fractures: analysis of 190 fractures. *J Orthop Trauma.* 1999;13(5):369-372.
6. DeWall M, Henderson CE, McKinley TO, Phelps T, Dolan L, Marsh JL. Percutaneous reduction and fixation of displaced intra-articular calcaneus fractures. *J Orthop Trauma.* 2010;24(8):466-472.
7. Chen L, Zhang G, Hong J, Lu X, Yuan W. Comparison of percutaneous screw fixation and calcium sulfate cement grafting versus open treatment of displaced intra-articular calcaneal fractures. *Foot Ankle Int.* 2011;32(10):979-985.
8. Tomesen T, Biert J, Frölke JP. Treatment of displaced intra-articular calcaneal fractures with closed reduction and percutaneous screw fixation. *J Bone Joint Surg Am.* 2011;93(10):920-928.
9. Marsh JL, Boyer JS, Sullivan J, Phisitkul P, Karam MD. A percutaneous technique for reduction and internal fixation of displaced intra-articular calcaneus fractures. *J Bone Joint Surg Am.* 2011;1(2):e9.
10. Schepers T, Schipper IB, Vogels LM, et al. Percutaneous treatment of displaced intra-articular calcaneal fractures. *J Orthop Sci.* 2007;12(1):22-27.
11. Tornetta P 3rd. Percutaneous treatment of calcaneal fractures. *Clin Orthop.* 2000;(375):91-96.
12. Stulik J, Stehlik J, Rysavy M, Wozniak A. Minimally-invasive treatment of intra-articular fractures of the calcaneum. *J Bone Joint Surg Br.* 2006;88(23):1634-1641.
13. Smerek JP, Kadakia A, Belkoff SM, Knight TA, Myerson MS, Jeng CL. Percutaneous screw configuration versus perimeter plating of calcaneus fractures: a cadaver study. *Foot Ankle Int.* 2008;29(9):931-935.