Original Article

THE SMALL PIN CIRCULAR FIXATOR FOR DISTAL Tibial Pilon Fractures With Soft Tissue Compromise

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ABSTRACT

A Monticelli-Spinelli small pin circular external fixator was used in combination with closed reduction or a limited open reduction internal fixation in five cases in an attempt to salvage a satisfactory result in distal tibia pilon fractures when associated soft tissue compromise prevented standard fixation with plates and screws. The small pin fixator enhances the ability to perform a closed reduction through a technique that uses distraction with pins in the tibia and calcaneus, combined with correction of angulation by tensioning wires with a stop nut. Small pin stabilization of these comminuted fractures allows early patient mobilization. The small diameter pins support the soft cancellous bone fragments. This technique attempts to combine the benefits of traction, external fixation, and limited internal fixation. We recommend this technique as a salvage procedure when plates and screws are contraindicated because of poor bone and soft tissue conditions.

The recent rise in the popularity of small pin circular fixators developed by Ilizarov, Monticelli-Spinelli, and others has focused primarily on the use of these devices for limb lengthening, correction of deformities, and nonunions. Although these devices have been used extensively in the Soviet Union, Italy, and other European countries for fracture care, there is little information published in the English literature. To the best of our knowledge, there is no published study dealing specifically with the use of the small pin circular fixator for juxtaarticular, intraarticular, distal tibia pilon fractures. We are reporting our preliminary results with this method of treatment, and have used a similar technique for proximal tibia fractures. The purpose of our study was to evaluate if this new technique offered any significant advantages over traction treatment or other forms of closed treatment. We used this technique only in cases where soft tissue injury or poor quality bone prevented the safe use of standard internal fixation with plates and screws.

MATERIALS AND METHODS

We have reviewed our first five consecutive cases where the Monticelli-Spinelli circular small pin external fixator was used to treat juxtaarticular, intraarticular fractures of the distal tibial plafond. The device was used only in situations where open reduction, internal fixation with plates was contraindicated because of soft tissue compromise or poor quality bone. Patients were treated between January 1988 and March 1989. This treatment method replaced traction treatment and other forms of closed treatment. We continue to perform open reduction internal fixation whenever possible.

Five cases were reviewed. Data were collected
regarding patient description, mechanism of injury, soft tissue injury, bone injury, timing of surgery, adequacy of reduction, intraoperative problems, postoperative problems, duration of hospital stay, duration in external fixator, duration in brace or cast, time to union, complications of treatment, range of motion of joints, and functional result. Soft tissue injury for closed fractures was classified according to the Tschere and Gotzen Classification (Table 1). Open fractures were classified according to the Gustilo Classification (Table 2). The tibial pilon fracture pattern was classified according to the Ruedi and Allgower classification (Table 3). The data are presented in Table 4.

**Closed Technique for Fractures With a Nondisplaced Joint Surface**

Metaphyseal fracture of the tibia is comminuted and associated with the distal third fibular fracture. There is a significant valgus deformity that is difficult to reduce by most closed methods. The distal tibia articular surface is relatively nondisplaced (Fig 1A).

Two 1.5 diameter transfixion wires are placed in the juxtaarticular bone to stabilize the intraarticular fracture fragments. The wires should be placed at least 15 mm from the joint surface to avoid synovial fluid contact (Fig 1B).

Two 2.0 mm diameter transfixion wires are placed in the mid-tibia diaphysis and two in the calcaneus. The tibial wires are connected to the full ring and the calcaneal wire to a 3/4 ring. The threaded connecting rods are used to obtain a distraction force at the fracture site (Fig 1C).

A 3/4 ring is placed at the level of the juxtaarticular pins. A 1.5 mm diameter wire with a stop nut is placed from medial to lateral through the angulated tibial metaphyseal fragment (Fig 1D).

Reduction of the metaphyseal component of the fracture is facilitated by applying tension to the wire with the stop nut. The juxtaarticular wires are then fixed to the ring with the wire holders for stability. The wires in the calcaneus enhance the overall stability of the system and keep the ankle in a neutral position to prevent an equinus deformity (Fig 1E).

The wires in the calcaneus may be removed at approximately 6 weeks to facilitate range of motion of the ankle joint (optional) (Fig 1F). The entire frame can usually be removed in 10 to 12 weeks if there is satisfactory healing. A cast may be substituted when necessary.

**Two-Stage Delayed Open Technique**

If the distal tibia articular surface has a severely displaced impacted fragment, it often cannot be reduced by closed methods. The metaphyseal component is comminuted and associated with the distal third fibular fracture. There is a significant valgus deformity that is difficult to reduce (Fig 2A).

**Stage 1:** Two 2.0 diameter transfixion wires are placed in the mid-tibia diaphysis and two in the calcaneus. The tibial wires are connected to a full ring and the calcaneal wires to a 3/4 ring. The threaded connecting rods are used to obtain a distraction force at the fracture site (Fig 2B).
Table 4

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Mechanism</th>
<th>Soft Tissue*</th>
<th>Fx. Class</th>
<th>Other Factors</th>
<th>Tx. Method§</th>
<th>Complication</th>
<th>Fixator Removal</th>
<th>Union</th>
<th>Ankle ROM</th>
<th>Function</th>
<th>Follow Up</th>
<th>Treatment Options&lt;br&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35</td>
<td>Fall, 12 ft.</td>
<td>Closed III</td>
<td>III</td>
<td>Healthy</td>
<td>M-S plus I.F.</td>
<td>None</td>
<td>3 mo.</td>
<td>8 mo.</td>
<td>Dorsi, 10; Fair; active plantar, 40°; related pain</td>
<td>NA</td>
<td>NA</td>
<td>6 wk.</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>Fall, 10 ft.</td>
<td>Open III-B</td>
<td>III</td>
<td>Alcohol abuse</td>
<td>M-S</td>
<td>Gastrointestinal hemorrhage; death</td>
<td>NA</td>
<td>NA</td>
<td>3 1/2 mo.</td>
<td>3 1/2 mo.</td>
<td>Early success</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>Fall, 15 ft.</td>
<td>Closed II</td>
<td>III</td>
<td>Drug abuse</td>
<td>M-S</td>
<td>None</td>
<td>2 mo.</td>
<td>NA</td>
<td>5 mo.</td>
<td>Dorsi, 10; Fair; active plantar, 35°</td>
<td>3 1/2 mo.</td>
<td>Success</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
<td>Fall, 15 ft.</td>
<td>Closed III</td>
<td>III</td>
<td>Alcohol abuse</td>
<td>M-S plus I.F.</td>
<td>None</td>
<td>3 mo.</td>
<td>NA</td>
<td>5 mo.</td>
<td>Dorsi, 10; Fair; active plantar, 35°</td>
<td>9 mo.</td>
<td>Success</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>Fall, 10 ft.</td>
<td>Closed III</td>
<td>III</td>
<td>Alcohol abuse</td>
<td>M-S</td>
<td>Could not achieve a good closed reduction. Poor soft tissue preserved or limited I.F.</td>
<td>3 mo.</td>
<td>NA</td>
<td>4 mo.</td>
<td>Dorsi, 5; Fair; plantar, 30°</td>
<td>6 mo.</td>
<td>Limited success</td>
</tr>
</tbody>
</table>

*Soft tissue classification for closed fractures (Tuchiner and Gotzen 0-III); Classification of open fractures, Gustilo (I-III)*

†Classification of distal tibia fractures (Braid and Alliger, 1969)

§M-S: Monticelli-Spinelli I.F. internal fixation (limited)

‡Treatment option vs cast, traction, or larger pin fixation

Fig 1: Technique for distal tibia pilon fractures treated with the circular small pin external fixator and closed reduction.

A 1.5 mm diameter wire with a stop nut is placed from medial to lateral through the angulated metaphyseal fragment. By applying tension to the wire with the stop nut, the metaphyseal fragment is reduced, lessening the extraarticular deformity and decreasing further soft tissue necrosis secondary to pressure from the underlying angulated metaphyseal bone spike (Fig 2C).

Stage 2: The second stage is delayed until the soft tissue condition improves. This may take 2 to 3 weeks, or longer. A single posterior lateral approach is performed that exposes the distal tibia-articular surface and the fibular fracture. The fibular fracture is anatomically reduced and stabilized with a plate and screws, restoring correct length and alignment of the fibula. The distal tibia articular fragments are reduced anatomically and stabilized.

Fig 2: Technique for distal tibia pilon fractures treated with the circular small pin external fixator, followed by delayed limited ORIF of the tibial articular surface and fibula.
Fig 3: A 35-year-old man fell from a 12-foot ladder sustaining a right tibia pilon fracture. Initial radiograph demonstrates severely comminuted, displaced, distal tibia, intraarticular fracture with associated fibula fracture (A).

Fig 3A.

Fig 3C: Clinical photograph on hospital day 4 demonstrating extensive skin blistering.

with the 1.5 mm transfixion wires (Fig 2D), or with an interfragmentary screw (Fig 2E). Any bone defects are filled with autogenous cancellous bone graft.

The Monticelli-Spinelli circular fixator provides stabilization for the tibia fracture and eliminates the need for applying a tibial plate. The calcaneus wires may be removed at approximately 6 weeks to facilitate range of motion of the ankle joint (optional) (Fig 2F). The entire frame can usually be removed at 10 to 12 weeks if there is satisfactory healing. A cast may be substituted when necessary.

Fig 3B: Radiographs after initial closed reduction and splint. Note persistent valgus deformity and articular displacement.

Fig 3B(1): AP view.  
Fig 3B(2): Lateral view.

Fig 3D: Clinical photograph on hospital day 4 after closed reduction and stabilization with the Monticelli-Spinelli Circular Fixator.
RESULTS

We subjectively classified our treatment option as either successful, limited success, or failure, compared to other forms of closed treatment options, such as traction, casting, or large pin external fixation (Table 4).

Three cases were considered successful salvage treatment options. Overall, treatment was considered superior to other forms of closed treatment. In general, we obtained a better reduction, decreased hospitalization time, earlier ambulation, better range of motion, and an overall functional end result equal to or better than that achieved by other forms of closed treatment. The actual result achieved was primarily associated with the specific severity of the initial injury. As expected, the more severe the injury, the poorer the end result.

Two cases were limited successes. In one case the circular fixator provided a good reduction and early stabilization; however, the patient died from a gastrointestinal hemorrhage at 6 weeks post-injury. In the other case of limited success, the circular fixator provided a significantly better reduction than was possible with a cast or traction; however, there was still some displacement of the impacted intraarticular fracture fragments. The severely compromised soft tissue prevented us from performing even a delayed limited open reduction. Although the early result has been satisfactory, we anticipate that the patient ultimately will require an ankle arthrodesis.

DISCUSSION

Comminuted juxtaarticular, intraarticular fractures of the distal tibial plafond are complex high-energy injuries affecting the bone and associated soft tissues.\textsuperscript{5,16} Open reduction with anatomic restoration of the fibula and the tibial articular surface, cancellous bone grafting of metaphyseal defects, and stable fixation with a medial or anterior tibia buttress plate and a lateral fibular neutralization plate is the treatment of choice for most of these fractures if the soft tissue and bone qualities permit internal fixation.\textsuperscript{12,15}

We strongly favor open reduction and plate fixation when the soft tissues permit. Evaluating the degree of soft tissue injury requires extensive experience.\textsuperscript{16} The soft tissue healing around the distal tibia is notoriously poor. The severe abrasions and contusions of the skin, subcutaneous fat, and muscle often result in delayed soft tissue necrosis. Surgical exposure of the fracture site will further compromise the soft tissues. Associated health problems also must be considered. Ovadia and Beals reported a signifi-
Fig 3F: Clinical photograph 24 days after initial injury. Skin and soft tissues have healed to allow a limited ORIF of the tibia articular surface and the fibula through a single posterolateral incision.

Fig 3G: AP radiograph demonstrating the combined internal and external fixation. The lateral radiograph was blocked by the metal hardware.

cantly higher complication rate in alcoholics. Attempting an open reduction with plate stabilization through compromised soft tissue significantly increases the risk of severe infection and complications which occasionally require amputation. Teeny et al noted that development of wound problems increased the incidence of deep infection six-fold, from 7% to 43% in the Type 3 fractures treated with standard AO technique for open reduction internal fixation. Our own internal review demonstrated up to a 40% deep infection rate when we attempted open reduction and plating of the tibia and fibula for Type 3 comminuted tibia pilon fractures with compromised soft tissues. Even the strong supporters of internal fixation agree that operating through poor skin conditions constitutes poor decision-making.

When severely compromised soft tissues or poor quality osteoporotic bone prevents internal fixation, what is the treatment of choice? There is little information in the literature because of the rarity of the situation. The literature has tended to exclude these cases from studies of internal fixation and they are frequently lumped with closed treatment studies. Traction has generally been the method of choice for this condition. We believe the results of traction treatment are similar to what we have achieved. We do feel, however, that traction treatment does have several limitations that we were able to improve on with the use of the small pin circular fixator. Traction treatment requires prolonged bed rest and hospitalization, with significant health and financial repercussions. Traction is limited in its ability to obtain a satisfactory reduction, especially in those fractures with combined intraarticular and juxtaarticular metaphyseal fracture components which tilt into valgus. An alternative method used previously has been the large pin external fixator.

Scheck reported seven cases using a screw traction external fixation apparatus combined with limited open reduction to reduce and stabilize the "key fragments." Satisfactory results were obtained in five of the seven cases. Large pin fixators are limited in their ability to obtain a satisfactory reduction of the fracture and also are associated with increased pin tract problems. Closed reduction and casting has been another option of treatment. It is limited in its ability to obtain a satisfactory reduction and maintain the reduction.

It is important to note that we have used this technique for the specific small subset of tibial pilon fractures where the quality of the soft tissues and bone was judged to be too poor to allow standard open reduction internal fixation. The technique has replaced traction treatment and other forms of closed treatment options. Thus, the treatment option we have outlined should be compared with a similar subgroup of patients.
Advantages of the Small Pin Circular Fixator

1. The circular fixation apparatus facilitated a better overall reduction than was possible with closed reduction alone or with traction treatment methods. The wire with the stop nut was found to be particularly helpful in obtaining a better reduction of the metaphyseal fracture component. The use of the wire with the stop nut facilitated fine adjustments to correct angular deformities. The wire with the stop nut can also provide interfragmentary compression of fracture fragments (Figs 3A-1).

2. The small transfixion pins under tension provide a support for the soft cancellous, osteoporotic bone fragments and maintains a reduction of the intraarticular fragments.

3. The use of the closed reduction technique or the percutaneous limited open reduction technique eliminated further soft tissue trauma. We believe this is a major benefit. Percutaneous placement of the transfixion pins allows excellent stabilization of the overall fracture pattern without involving soft tissue stripping.

4. The circular fixation frame allows excellent stabilization of the fracture for early ambulation of the patient, reducing the length of hospital stay and the cost, compared to prolonged traction treatment.

5. The use of the external fixation frame allows access to the skin for continued care of skin abrasions, not possible with cast treatment.

6. Use of a single posterolateral incision significantly reduces the incidence of postoper-
ative wound complications. The fibula is anatomically reduced and stabilized with a neutralization plate. The articular surface of the tibia is anatomically reduced. Metaphyseal bone defects are filled with iliac cancellous bone graft. The circular fixator enhances reduction and stabilization of the tibia fracture, avoiding the need for an anterior or medial incision.

7. The circular fixator allows initial stabilization with distraction pins in the tibia and calcaneus, helping to stabilize the fracture and keeping the ankle in neutral to prevent an early equinus deformity. The pins in the calcaneus can usually be removed in 4 to 6 weeks to allow range of motion of the ankle. Further stabilization is provided by the juxta-articular pins. The entire circular frame apparatus is easily removed at 10 to 12 weeks.

Problems Associated With This Technique
Use of the circular small pin fixator requires technical experience with the use of the fixator. There is a high degree of "tinker toy" frustration associated with the use of all circular external fixation systems. Application of the device is tedious and time-consuming, requiring a thorough knowledge of neurovascular anatomy.

Use of the circular external fixation system has the problems associated with potential pin tract infection, a concern with all external fixation techniques. Although the use of small pins significantly reduces pin tract problems, it does not completely eliminate them. Although we did not experience any pin tract infection in this series of distal tibia fractures, we have experienced a septic knee joint complication when using the circular fixator for proximal tibial plateau fractures. The potential problem of joint sepsis must be considered when placing the pins within intimate contact of the joint. We now believe it is very important to place pins at least 15 mm away from any joint surface. This should reduce the chance of synovial fluid contamination. It is very important to monitor the status of the pin sites, especially in the juxtaarticular location. We recommend removal of any pin demonstrating pin tract irritation.

Conclusion
We recommend the use of the small pin circular fixator for treatment of complex distal tibial fractures as a salvage procedure, to replace other methods of closed treatment when the soft tissue injury or bone quality does not permit standard internal fixation with plates and screws. We believe it is a helpful addition to our armamentarium for complex fracture treatment. Because of the multifactorial complexity of these injuries, there is no universal method of treatment applicable in all cases.

References