Some tibial shaft fractures cannot be accurately reduced using closed or percutaneous techniques during an intramedullary nailing procedure. Under these circumstances, a formal open reduction can be performed. Direct exposure of the fracture facilitates accurate reduction but does violate the soft tissue envelope. The purpose of this study was to evaluate the safety and efficacy of open reduction prior to intramedullary nailing.

Using the trauma database at a Level I trauma center, 11 uncomplicated closed displaced tibia fractures treated with formal open reduction prior to intramedullary nailing were identified and matched with a cohort of 21 fractures treated with closed reduction and nailing. The authors attempted to match 2 controls to each patient to improve the power of the study. Clinical and radiographic outcomes were compared. All fractures ultimately healed within 5° of anatomic alignment. No infections or nonunions occurred in the open reduction group, and 1 deep infection and 1 nonunion occurred in the closed reduction group. No significant differences existed between the study groups.

Although closed reduction and intramedullary nailing remains the treatment of choice for most significantly displaced tibial shaft fractures, open reduction with respectful handling of the soft tissue envelope can be safe and effective and should be considered when less invasive techniques are unsuccessful.
Historically, open reduction and internal fixation of tibial shaft fractures has been associated with high infection and nonunion rates. However, closed reduction and intramedullary nail fixation avoids soft tissue dissection around the fracture and has evolved into the treatment of choice for most unstable fractures of the tibial diaphysis and some proximal and distal metaphyseal fractures.

In general, indirect reduction techniques are used to reestablish proper tibial length, alignment, and rotation prior to nailing while preserving the local fracture biology. Because of the high priority assigned to preserving the soft tissues at the fracture site, some authors report that open reduction techniques should be avoided. However, nonanatomic reduction has been shown to decrease the strength of a healing fracture and to be a significant risk factor for reoperation. Malreduction can also compromise the mechanical axis of the limb, adversely affecting knee and ankle function. In some cases, interposed soft tissue, intramedullary bone fragments, or complex deforming forces mean that reduction is only possible with open techniques.

In the authors’ current practice, indirect reduction techniques are initially used to reduce tibia fractures prior to nail insertion. However, if appropriate reduction is not possible using less invasive techniques, a formal open reduction is considered. The purpose of this study was to compare the outcomes of closed tibial fractures treated with intramedullary nail fixation preceded by closed vs open reduction. The hypothesis was that open reduction through a limited incision and respectful handling of the soft tissue envelope does not increase the risk of complications.

**Materials and Methods**

After receiving institutional review board approval, a retrospective review of a prospectively maintained trauma database was performed. Fractures were coded according to the AO/Orthopaedic Trauma Association (OTA) fracture classification system by trained orthopedic trauma fellows. All closed OTA type 42 tibia fractures occurring in patients 18 years or older and treated with intramedullary nail fixation by 1 of 3 fellowship-trained orthopedic trauma surgeons (D.B., J.B., G.D.) between January 2000 and September 2009 were identified. Open fractures, fractures complicated by compartment syndrome, and fractures reduced by percutaneous clamp placement were excluded. For comparison, patients were matched based on age (±6 years) and OTA fracture classification (location and type) with patients who were treated with closed reduction and intramedullary nailing. The authors attempted to match 2 controls to each patient to improve the power of the study.

Demographic data were extracted from the medical records, including patient age, sex, presence or absence of vascular or nerve injury, and smoking history. Nonunion and infection rates were also recorded. Nonunion was defined by the need for an additional procedure to promote bony healing. Infection was defined as a requirement for antibiotic treatment or the need for irrigation and debridement.

Radiographs at the time of fracture healing were evaluated for the quality of reduction. Angulation was measured in the coronal and sagittal planes by 2 fellowship-trained orthopedic trauma surgeons (J.B., G.D.) who were blinded to the whether the reduction was obtained through an open or closed technique. Discrepancies in measurement were resolved by taking the mean between the 2 measurements. Malalignment was defined as greater than 5° of angulation in any plane.

**Results**

A retrospective review of the trauma database identified 190 patients with OTA type 42 tibia fractures treated operatively at a Level I trauma center by 1 of 3 surgeons between January 1, 2000, and September 30, 2009. Fractures with articular involvement of the knee or ankle were excluded. Of the remaining 166 fractures, 136 were closed, 40 were open, and 20 were associated with compartment syndrome. Seventy-three fractures were treated with closed reduction and 32 with percutaneous clamping prior to nailing. Eleven closed fractures of the tibial shaft not associated with compartment syndrome were treated with formal open reduction prior to intramedullary nail fixation. These were matched based on patient age and OTA fracture classification, with 21 fractures treated with closed manipulative reduction and intramedullary nail stabilization.

The study group included 5 OTA type 42A, two type 42B, and 4 type 42C fractures. The control group included 10 type OTA 42A, four type 42B, and 7 type 42C fractures. No patient in the open reduction group and 2 patients in the closed group underwent concomitant open reduction and internal fixation of their associated fibula fractures.

The baseline demographic characteristics for the study patients are summarized in Table 1. No vascular or nerve injuries occurred in either group. The indications for open reduction included obstructive intramedullary cortical fragments in 6 patients and an inability to obtain and maintain an acceptable closed reduction in 4 patients. In 1 patient, the indication for open reduction could not be determined. The surgical outcomes are summarized in Table 2. No statistically significant difference existed in the nonunion or infection rates between the groups. At final follow-up, no fracture was malaligned in either group.

**Discussion**

Historically, open reduction and internal fixation of tibial shaft fractures has been associated with devascularization of the fracture fragments, leading to compromised outcomes. Most surgeons favor indirect reduction techniques with
the goals of restoring appropriate length, alignment, and rotation without violating the soft tissue envelope.

However, inadequate reduction of a tibial shaft fracture can compromise outcome. Nonanatomic reduction in a rabbit model has been shown to compromise fracture biomechanics, with cortical continuity being the best single predictor of strength of fracture healing. A recent clinical investigation also identified a lack of cortical continuity as one of three factors predictive of reoperation following operative treatment of tibial shaft fractures. Multivariate analysis in that trial revealed a relative risk of 8.3 for fractures with less than 50% cortical continuity, leading the authors to emphasize the importance of reduction quality as a factor that surgeons can control. Another contemporary study suggests that percutaneous reduction techniques can be safely used in the setting of closed tibia fractures treated with intramedullary nailing. The current authors reported a series of 40 fractures reduced using open techniques, including 22 fractures reduced with percutaneous clamps and 5 with compartment syndrome. Thirteen fractures were treated with formal incisions that had lengths longer than 1 cm. No statistically significant differences existed between the groups in terms of infection or fracture healing. The authors concluded that open reduction is a safe technique and that the failure to judiciously use such techniques can result in prolonged surgery, increased radiation exposure, further soft tissue injury from multiple reduction attempts, and acceptance of suboptimal osseous alignment. Although the current authors agree with this rationale, their may be more applicable to percutaneous and not open reduction.

To the current authors’ knowledge, this article is the first to report a series of patients with acute closed tibial shaft fractures treated with formal open reduction and internal fixation followed by intramedullary nailing, along with a matched control group of patients who underwent closed reduction prior to nailing. Indications for open reduction included the inability to obtain or maintain an appropriate reduction using closed or percutaneous techniques and the presence of obstructive intramedullary cortical fragments. When matched with a retrospective cohort of patients treated with closed reduction and intramedullary nailing, no increase occurred in infection or compromised fracture healing. Alignment at the time of fracture healing was similarly unaffected by open vs closed reduction techniques. Overall, patient outcomes were not compromised when formal open reduction was performed prior to intramedullary nailing. Rather, reliable fracture healing and high-quality reductions were achieved in a group of challenging fractures that could not be reduced using less-invasive techniques by an experienced group of orthopedic trauma surgeons. The current findings are comparable with those of Afsari et al, who reported quality fracture reductions and high union rates after open reduction and intramedullary nailing of subtrochanteric femur fractures.

These formal open exposures and reductions are used only after less-invasive techniques have proved unsuccessful, and they must be respectful of the traumatized soft tissue envelope. The current authors do not advocate extensive soft tissue stripping or the use of aggressive, self-retaining retractors or circumferential and crushing reduction clamps. Incision placement is also important. The authors avoid the most tenuous skin on the subcutaneous medial face of the tibia and most commonly use an anterolateral or posteromedial incision depending on the fracture and soft tissue details of the injury.

Limitations of this study are its retrospective design and short follow-up. In addition, the series included 11 closed

### Table 1

**Baseline Demographic Characteristics of Cases and Controls Demonstrating No Significant Difference Between Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Open Reduction (n=11)</th>
<th>Closed Reduction (n=21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (range), y</td>
<td>38.2 (16-56)</td>
<td>37.6 (15-53)</td>
<td>.90</td>
</tr>
<tr>
<td>No. of men</td>
<td>8</td>
<td>15</td>
<td>.938</td>
</tr>
<tr>
<td>No. of smokers</td>
<td>5</td>
<td>10</td>
<td>.981</td>
</tr>
<tr>
<td>No. of diabetes mellitus</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Abbreviation: N/A, not applicable.**

### Table 2

**Outcomes of Surgical Treatment in Case and Control Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Open Reduction (n=11)</th>
<th>Closed Reduction (n=21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>1</td>
<td>1</td>
<td>.478</td>
</tr>
<tr>
<td>Nonunion</td>
<td>0</td>
<td>1</td>
<td>.444</td>
</tr>
<tr>
<td>Malunion</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Abbreviation: N/A, not applicable.**
fractures that underwent open reduction prior to nailing and, therefore, may have been underpowered to detect a difference between the treatment groups. Also, formal functional outcome scores were not available in these patients.

**Conclusion**

Closed reduction of tibial shaft fractures prior to intramedullary fixation is the preferred technique. However, closed or percutaneous techniques are not effective in some cases, and appropriate reduction is only attainable through formal open techniques. When open reduction is performed though a well-placed incision with respectful soft tissue handling, it is a safe and effective technique. Ongoing research that includes a larger number of patients with functional outcome measures is needed to confirm these findings.

**References**