INTRODUCTION: Fractures of the distal tibia metaphysis are often unstable and require surgical treatment to avoid shortening or malunion1. Authors have reported success and failure with functional bracing, plate fixation, intramedullary nailing, and external fixation2. The role of the fibula in fracture stability is also undetermined3. Cadaveric lower limbs with simulated distal tibia and fibula fractures were repaired using conventional plates, locked-plates, or intramedullary (IM) nails. Each specimen was sequentially loaded to determine the fixation method with optimal stability. Our hypothesis was that intramedullary nails may provide optimal stability without requiring fibula fixation.

METHODS: Six paired fresh frozen cadaveric limbs with soft tissues intact were disarticulated at the knee and had a right heel DEXA scan. The twelve specimens were divided into a balanced incomplete block design based upon the bone mineral density. Each specimen was potted proximally at the tibia plateau and attached distally to a footplate with calcaneus and forefoot Steinman pins. The subtalar, ankle, and tibiofibular joints were allowed free motion.

For each test, specimens were nondestructively evaluated in sequence beginning with 4.5Nm of torsion (applied at 0.25Nm/s), followed by compressive axial loads of 150N and 600N (applied at 50N/s)2. Motion of the proximal and distal tibia fracture fragments was recorded using an extensometer (accurate to ±0.03 mm) and an infrared camera-based measurement system (accurate to ±0.1 degrees and ±0.1 mm). A sequential testing protocol was used to evaluate three methods of tibia fixation, with and without fibula fixation, for both a corticotomy and a 1cm fracture gap. Each tibia and fibula received a corticotomy 4 centimeters above the joint line. The specimens were then split into three groups. Group A had a standard AO medial distal tibia plate (Synthes®). Group B had a locking peri-articular medial distal tibia plate (Synthes®). Group C had a reamed IM tibial nail (Synthes Expert Tibial Nail®) with three distal locking screws. Specimens were then tested in torsion and compression beginning with Test #1 where only the tibia fracture was fixed. For Test #2 the fibula fracture was then fixed with a 1/3 tubular plate. In Test #3 the tibia and fibula corticotomies were expanded with an oscillating saw to 1 cm gaps without removing the fixation. Finally for Test #4 the fibula plate was removed.

The data were analyzed statistically using ANOVA with the Tukey method for post-hoc comparisons (significance at p<0.05). Prior to statistical analysis, a log transform was performed to normalize variance.

RESULTS: The mean heel bone mineral density scores between the three treatment groups were not significantly different (p=0.4) for the specimens included in this study.

For Test #1, with isolated fixation of the tibia corticotomy and no fibula fixation, there were no differences between the AO plate, locked plate, and IM nail groups during axial loading (Fig 1). In torsion, however, the AO plate allowed at least 3 degrees more rotation than either the locked plate (p=0.015) or IM nail (p<0.001). The IM nail was the most stable construct in torsion, reducing motion 1.3 degrees further than the locked plate (p=0.009).

Fixation of the fibula in Test #2 reduced the mean fracture motion in axial loading and torsion as compared to tibia fixation alone, but the changes were very small and not significant. In axial loading there were no differences between the three groups. In torsion, however, the AO plate group mean rotation was 4.3 degrees, 3 degrees greater than the locked plate (p=0.001) and IM nail groups (p=0.001).

In Test #4 only the tibia was fixed across a 1cm gap. In torsion, there were significant differences between all fixation methods (p<0.007 for all), with IM nails providing the least motion. At axial loading to 600N no differences were noted between the groups, although at 150N, IM nails provided less motion than AO plates (p=0.007).

During axial loading at 600N the collapse of most specimens into valgus alignment was observed when the 1cm gap was present. The angulation of this collapse was calculated from the camera measurement system data. With locked fixation, the IM nail prevented valgus collapse better than plate constructs (p=0.05, Table 1).

Fixation of both the tibia and fibula across a 1cm gap in Test #3 reduced mean motion in only the AO and locked plate groups although differences were not significant. Adding a plate to the fibula decreased the valgus collapse seen in the previous test (with isolated tibia fixation) in both the AO plate (p=0.03) and locked plate groups (p=0.07).

DISCUSSION: Although each treatment group was small, several significant differences in fracture motion were encountered. Despite providing axial stability, the AO plate did not provide rotational stability in this study. Adding a fibula plate to the AO plate construct decreased the valgus collapse with axial loading, but still did not prevent rotation in torsion.

Locked plates allowed more axial motion and angulation than IM nails, but based upon this study the differences were not significant. Plating the fibula improved the locked plate stability to levels equivalent with IM nails, except in torsion. Additional samples may demonstrate other statistical differences, but these small differences may not be clinically relevant. It should also be noted that different constructs not considered in this study, such as anterolateral locked plates or IM nails with two interlocking bolts, may perform differently.

Finally, fixation of the fibula provided no increase in stability to an IM nail, but on average increased tibia fracture stability in the AO and locked plate groups, particularly in the presence of a 1cm gap. This suggests that the fibula may only require fixation if there is bone loss or comminution at the fracture site and plates are used for tibia fixation. Despite these findings, fixation of the fibula still has clinically relevant functions such as attaining proper alignment and length of the tibia fracture during surgical fixation.


Table 1: Mean (± SD) valgus rotation under a 600N axial load.

<table>
<thead>
<tr>
<th>Tibia fixation</th>
<th>Isolated tibia fixation</th>
<th>Tibia + fibula fixation</th>
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</thead>
<tbody>
<tr>
<td>AO plate</td>
<td>6.6 ± 3.7</td>
<td>1.5 ± 0.1</td>
</tr>
<tr>
<td>Locked plate</td>
<td>5.8 ± 1.6</td>
<td>1.4 ± 0.5</td>
</tr>
<tr>
<td>IM nail</td>
<td>1.8 ± 1.8</td>
<td>1.4 ± 1.9</td>
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COMPARISON OF FIXATION METHODS FOR DISTAL TIBIAL METAPHYSEAL FRACTURES

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