Biomechanical comparison of fixation of type-I fractures of the lateral tibial plateau

IS THE ANTIGLIDE SCREW EFFECTIVE?

P. J. Parker, K. B. Tepper, R. J. Brumback, V. P. Novak, S. M. Belkoff
From the R. Adams Cowley Shock Trauma Centre, University of Maryland, Baltimore, USA

Type-I fractures of the lateral tibial plateau were simulated by osteotomy in 18 pairs of unembalmed cadaver tibiae. One fracture of each pair was fixed with two lag screws whereas the contralateral site was stabilised with three lag screws, or two lag screws plus an antiglide screw. The lateral plateau was displaced downwards using a servohydraulic materials testing machine and the resulting force and articular surface gap were recorded. Yield load was defined as the maximum load needed to create a 2.0 mm articular offset at the fracture line. The yield loads of the three-lag-screw (307 ± 240 N) and antiglide constructs (342 ± 249 N) were not significantly different from their two-screw control constructs (231 ± 227 and 289 ± 245 N, respectively). We concluded that adding an antiglide screw or a third lag screw did not provide any biomechanical advantage in stabilising these fractures.

Received 11 May 1998; Accepted after revision 6 November 1998

We obtained 18 pairs of fresh cadaver tibiae which, after being wrapped in saline-soaked towels, were stored in sealed plastic bags at -20°C. Seven pairs were from male cadavers and 11 were from female. The mean age of the donors was 78 ± 10 years. Before testing, each pair was thawed at 4°C for 24 hours. All soft tissues were removed and the specimens were wrapped in saline-moistened gauze to prevent dehydration. Each tibia was cut across the midshaft and the distal part of the proximal half was secured in specially designed fixtures using an epoxy resin (Swiss Glass, Composite Inc, Lebanon, Ohio) so that the long axis of the bone was vertical in both the antero-posterior and lateral planes. One of each pair of tibiae was randomly selected as the control and was repaired with two cancellous lag screws. The contralateral tibia was repaired using one of two different fixation techniques. In addition to the two lag screws inserted in the same manner as in the control side, the tibia was stabilised with either a third lag screw or an antiglide screw and washer. (Fig. 1). The antiglide screw was inserted at the distal apex of the fracture so that the washer overlapped the fracture fragment and compressed it; nine tibiae were repaired with three lag screws and nine using the antiglide screw.

The 3.2 mm drill holes for the appropriate number and location of lag screws were made using the standard AO

©1999 British Editorial Society of Bone and Joint Surgery 0301-620X/99/39100 $2.00
technique. After the pilot holes had been drilled, an osteotomy of the proximal tibia was performed using an autopsy saw. This transarticular osteotomy was begun at the most medial portion of the lateral plateau, just lateral to the cephalad curvature of the base of the tibial spines. The osteotomy was almost vertical, angling slightly laterally to exit at the point of maximal change in curvature on the inferolateral aspect of the proximal tibial metaphysis. This created an osteotomy approximately 20° off the vertical plane, simulating a Schatzker type-I fracture of the lateral tibial plateau.

The lateral plateau was reduced and held with a bone tenaculum. The osteotomy was fixed with two or three 6.5 mm diameter lag screws with 32 mm threads. In those specimens treated by an antiglide screw the apex of the fracture was then drilled with a 3.2 mm drill bit and a cortical screw of appropriate length with a washer was inserted. Anteroposterior and lateral radiographs were taken of each specimen to record the placement of the screw.

Each repaired tibia was rigidly attached to the base of a servohydraulic testing machine (Instron, Canton, Massachusetts) by its potted distal end (Fig. 2). A polyurethane load applicator was driven vertically downwards, so that axial loading was applied to the lateral tibial plateau at a rate of 0.1 mm/s. Care was taken to load only the articular surface of the lateral tibial plateau. A load transducer (Sensotech, Columbus, Ohio) mounted above the tibia measured the force transmitted to the lateral plateau, while displacement of the lateral fragment was measured using a non-contact video system (BTS Corporation, Milan, Italy) designed to measure point-wise kinematic movement. This system consisted of a single charged-coupled device camera equipped with a synchronised infrared flash, real-time image-processing unit, and 1.0 mm retroreflective markers.

Two markers were placed on each side of the repaired osteotomy just before testing and were tracked at 25 Hz during each test. The resolution of the video system was 0.003 mm and the accuracy was 0.07 mm.

Displacement of the fragments of the fracture was analysed for movement parallel and perpendicular to the fracture line, i.e., fracture gapping and distal migration. Most studies agree that an adequate reduction of displaced articular injuries should be within 2 to 3 mm of anatomical alignment. We therefore considered that the fixation failed when displacement of the fracture of more than 2.0 mm occurred. Thus, yield force was defined as the peak load occurring during displacement of the fragment of the lateral plateau of up to 2.0 mm. Yield loads for the three-lag-screw and the antiglide treatment groups were compared with those for their respective two-screw controls using paired Student’s t-tests with significance set at p < 0.5.

Results

The mode of failure in all specimens was by distal translation of the lateral fragment along the plane of the osteotomy, with the lag screws cutting through the cancellous bone of the fragment of the tibial plateau. There was no screw pull-out or bending of the screws as assessed by radiographs taken after each test. Tibiae repaired with the antiglide screw showed a mean yield load of 342 ± 249 N (SD), whereas those fixed with two screws had a mean yield load of 289 ± 245 N (Table I). Similarly, tibiae repaired by three lag screws had a mean yield load of 307 ± 240 N compared with a mean value of 231 ± 227 N in the two-screw group. Neither of the paired differences was statistically significant. Comparison of the yield loads between
those tibiae repaired by three lag screws and those stabilised with an antiglide screw was not appropriate as these two treatment groups had different control groups.

Table I. The yield loads (N) in the tibiae of the control and treatment groups

<table>
<thead>
<tr>
<th>Specimen number</th>
<th>Control (2 screws)</th>
<th>Three screws</th>
<th>Antiglide screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.1</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>669</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>56.5</td>
<td>78.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>187</td>
<td>716</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>91.2</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>187</td>
<td>261</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>230</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>547</td>
<td>699</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>78.3</td>
<td>234</td>
<td></td>
</tr>
</tbody>
</table>

Mean (± sd): 231 ± 227 307 ± 240

Discussion

Our study has shown that no advantage is provided by the addition of a third lag screw or an antiglide screw in the fixation of type-I split fractures of the lateral plateau. Although both of the three-screw fixations showed higher yield loads than the two-screw group, the differences were not statistically significant. Earlier studies suggested that plating provided the most secure fixation of injuries to the lateral tibial plateau, especially in osteoporotic bone. Published biomechanical studies give conflicting opinions as to whether plate fixation causes a significant increase in stiffness to the fracture over other methods. The results of our study may be biased in that the tibiae tested were from elderly donors, and dense cancellous bone, common in younger patients, may not show the same biomechanical behaviour. The mode of failure in our study was at the junction between the shaft of the lag screws and the cancellous bone of the tibial fragment. Theoretically, with increasing density of the lateral fragment, other modes of failure, such as pull-out of the articular surface or deformation of the screw, may occur. Many fractures of the lateral plateau have an element of depression associated with a lateral split of the plateau, the so-called type-III fracture. Our investigation did not address the ability of these percutaneous techniques to maintain the reduction in these injuries.

The fibula was removed in all specimens and therefore any contribution that it may make to the stability of the fragment of the fracture was not addressed. We only tested axial loading of the fixed fracture. Stresses across the joint during flexion and extension of the knee, or twisting, may create different forces on the stabilised fracture.

Our study is similar to that recently published by Toolan et al. They used different methods to assess the stability of the fracture, and also measured the fatigue strength of three different types of fixation for fractures of the lateral tibial plateau. They found no statistical difference in type-I fractures stabilised with three 6.5 mm diameter lag screws, the antiglide method, or lateral buttress plating in initial displacement, cyclic loading, or loads to failure. Our investigation used two lag screws as a control group because many split fractures of the lateral plateau are not large enough to accept three 6.5 mm diameter cancellous screws with washers.

The addition of a third screw, whether as a lag or an antiglide screw, did not affect the stiffness of fixation and offered no apparent biomechanical advantage in the stabilisation of split fractures of the lateral plateau of the tibia. Further investigation of more comminuted fractures, involving greater depression of the articular surface of the proximal tibia, is needed before recommending fixation of more extensive fractures of the lateral plateau by a lag screw.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References