Failure of Fixation of Tibial Plateau Fractures

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Objective: To define the failure of fixation in tibial plateau fractures, detect its incidence, and determine the contributing factors.

Design: Mail survey and literature review were used to define the fixation failure; this definition was applied to a radiologic review of patients who were treated surgically for tibial plateau fracture at a Level 1 trauma unit for a three-year period from 1993 to 1995.

Patients and Setting: Forty-two consecutive patients treated surgically at our trauma unit for tibial plateau fractures were studied retrospectively, specifically for loss of fixation. Factors that might affect the fracture fixation were reviewed, including age, mechanism of injury, type of fracture, bone quality, severity of fragmentation, severity of displacement, time to surgery, operating time, fixation method, use of bone graft, postoperative bracing, and mobilization.

Main Outcome Measures: The main outcome measure was failure of fixation, by using criteria defined by the result of a mail survey of experts and literature review.

Results: Using a strict definition of radiologic failure of fixation, we reported an overall 31 percent rate of failure of fixation: 79 percent in patients older than sixty years compared with 7 percent in younger patients. The statistically significant associations with loss of reduction were age more than sixty years, premature weight bearing, preoperative displacement, fracture fragmentation, and severe osteoporosis.

Conclusion: It is logical to define failure of fixation using the same measures considered as indications for reduction and fixation. Using these strict criteria, the incidence of radiologic failure was much higher than previous published series. In the elderly this was unacceptably high, and treatment goals should be limited to restoring stability and alignment.

Key words: Fixation failure, Tibial plateau fracture, Loss of position, Elderly.

Failure of implant fixation in tibial plateau fractures has received limited attention in the published literature, suggesting a limited effect on clinical outcome. Bowes et al. studied 110 patients with tibial plateau fractures and reported only one case with loss of fixation after open reduction (6). Delamarter et al. studied thirty-nine fractures of the tibial plateau associated with ligament injury and found six cases of failure of fixation (9). Benirschke et al. reported fourteen complex open fractures (Schatzker Types V and VI) and had two cases with loss of reduction of five millimeters (4). Marsh et al. studied twenty-one complex fractures of the tibial plateau, which were treated with combined external and limited internal fixation; they reported one case of loss of reduction (seven-millimeter step-off) and another two cases of 8 degrees of varus malignment (21). Hohl in his series found 18 percent of patients had a loss of position of more than two millimeters in fractures treated with open reduction and internal fixation, and 9 percent had loss of position in cases treated with closed reduction (14). In most reports failure of fixation is not defined.

To the authors it seemed illogical to accept a measured loss of position after surgery any different from the indication for reconstruction. Therefore, the preoperative unacceptable x millimeters of depression or y degrees of angulation should also define failure of fixation. The indications for surgical reduction of tibial plateau fractures in the literature range from two to ten millimeters of step-off (Table 1). Because malalignment is considered an important factor in predicting the outcome, most authors do not accept >5 degrees varus or valgus angulation (7,16,21,30,34).

In contrast, many authors report good results after nonanatomic reduction for tibial plateau fractures (2,12,13,26,27,29). Long-term studies of more than twenty-years of follow-up indicate that there are inconsistencies between residual articular depression and the development of osteoarthritis (20). The incidence and effect of loss of fixation may therefore not be obvious in reviews using clinical outcome only.
The aims of this study were as follows:
1. To define the radiologic failure of fixation of tibial plateau fractures.
2. To detect its incidence and determine the contributing factors.

PATIENTS AND METHODS

Part 1

In support of the concept that failure of fixation should be defined by the same radiologic parameters used as the indications for surgery, the authors of leading publications on tibial plateau fractures were asked by personal communication to define the following:
1. Failure of fixation in tibial plateau fractures.
2. Valgus or varus angulation (in degrees) and step-off (in millimeters) they would accept on the follow-up radiographs before considering the case a failure of fixation.

The responses are summarized in Table 2.

The authors of this study concluded from the sum-mated responses that a definition of radiologic failure of fixation was as follows: a loss of the fracture reduction, resulting in either a step-off (depression) of the articular surface of more than three millimeters, or malalignment of the extremity of >5 degrees (Table 3). Failure would also include loss of fixation either by loosening or breakage of the implants.

Part 2

Forty-two consecutive patients were treated surgically at our trauma unit for tibial plateau fractures during the period from January 1993 to December 1995, and they were studied retrospectively. All the patients were followed clinically and radiologically to full union. The mean age was forty-nine years (range 16 to 83 years). Fourteen patients were older than sixty years. There were twenty-two female and twenty male patients. Five patients had additional ipsilateral and five had contralateral lower limb fractures.

Five were open fractures Gustilo Grade IIIA (11); in this group an immediate temporary spanning external fixator was used and changed to definitive fixation during the first ten days. All the surgical procedures were performed either by or under the direct supervision of a consultant orthopaedic trauma surgeon, trained in AO techniques. The implants used are shown in Table 4.

The indication for surgery in each case was, or exceeded, a displacement or step-off of more than three millimeters, malalignment of >5 degrees, or instability in full extension of >10 degrees.

The postoperative management for each patient included early mobilization using continuous passive motion. The patients were instructed to be non-weight bearing initially for between six and twelve weeks, followed by partial weight bearing for a further four to six weeks.

Radiologic Evaluation

The fractures were graded using both Schatzker’s classification (30) (Table 5) and the AO comprehensive classification of long bone fractures (Table 6). This allowed comparison with other published series. Classification and measurements were determined independently by two researchers. Interobserver differences were resolved by remeasurement by the senior author. The following aspects were assessed:

The severity of fragmentation was rated by counting the greatest number of bone fragments on either plain radiographs or computed tomography scan and then classified as follows:

<table>
<thead>
<tr>
<th>Study</th>
<th>Step-off (mm)</th>
<th>Varus (degrees)</th>
<th>Valgus (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holzach (Davos)</td>
<td>&gt;2</td>
<td>2–5</td>
<td>2–5</td>
</tr>
<tr>
<td>Anglen (Missouri)</td>
<td>2–3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Lachiewicz (NC-USA)</td>
<td>&gt;2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>T. Watson (Michigan)</td>
<td>—</td>
<td>3–5</td>
<td>3–5</td>
</tr>
<tr>
<td>J. L. Marsh (Iowa)</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>K. J. Koval (New York)</td>
<td>&gt;2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>De Coster (New Mexico)</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>M. Hohl (California)</td>
<td>&gt;2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>C. Rorabeck (Ontario)</td>
<td>&gt;2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Schemitsch (Toronto)</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>S. Gausewitz (California)</td>
<td>Any change in the position is failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. Whitelaw (Massachusetts)</td>
<td>&gt;2</td>
<td>&gt;3</td>
<td>&gt;3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure</th>
<th>Step-off (mm)</th>
<th>Condylar widening (mm)</th>
<th>Plateau tilt (varus–valgus) (degrees)</th>
<th>Plateau slope (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;3</td>
<td>&gt;5</td>
<td>&gt;5</td>
<td>&gt;5</td>
</tr>
</tbody>
</table>

TABLE 2. The criteria of failure of fixation of tibial plateau fracture, from different authors (personal communications)

TABLE 3. The criteria for failure of fixation

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• Simple fragmentation: three bone fragments or less.
• Complex fragmentation: more than three bone fragments.

The presence of severe osteoporosis was determined clinically by an intraoperative assessment of bone quality and radiologically using proximal tibial films using Foltin’s (10) Grades I and II (marked or severe diminution of trabecular and cortical bone) on the preoperative radiographs.

Fracture displacement and angulation were measured in all groups by the following techniques (Fig. 1):

1. The tibial plateau tilt—the angle in a varus and valgus direction as measured on the anteroposterior projections perpendicular to the long axis of the tibia.
2. The plateau slope—the angle the tibial plateau makes with a line perpendicular to the long axis of the tibia on the lateral projection.
3. The articular step-off—the maximal depression or displacement of the articular surface in an axial direction on anteroposterior, lateral, or oblique projections.
4. The condylar widening—measured in comparison with the intact contralateral tibia or with the ipsilateral femoral condyles as an alternative.

Preoperative displacement was graded according to severity (Table 7).

The loss of position was determined by comparing two sets of radiographs for each patient: the immediate operative films and follow-up interval radiographs to union (minimum three months).

Statistical analysis was performed using $\chi^2$ and Fisher exact tests.

- Simple fragmentation: three bone fragments or less.
- Complex fragmentation: more than three bone fragments.

### RESULTS

Based on our definition of loss of fixation, thirteen patients (31 percent) had failure of fixation. These are individually detailed in Table 8.

Operative findings did not result in the reclassification of any case. The relationship between the failure and the fracture classification (Schatzker and AO) is shown in Tables 5 and 6.

Three of the thirteen failures were for loss of alignment into varus or valgus, three were for a combination of tilt and step-off deformity, and five were for recurrence of step deformity only. One patient developed a reverse plateau slope deformity, and one collapsed into valgus with worsening of both step and gap deformity.

### Age

There was a strong association between age and failure of fixation. The thirteen fixations that failed were in patients who had a mean age of 69.6 years. This is compared with the twenty-nine fixations that did not fail in patients whose mean age was thirty-eight years ($t$ test, $p < 0.001$). Eleven (85 percent) of the patients with failed fixation were older than sixty years. This represents a failure rate of 7 percent in the younger than sixty years group and 79 percent in the more elderly group (Fig. 2).

All nine patients with recurrence of step deformity were sixty years of age or older.

### Osteoporosis

All the patients who had marked osteoporosis in our study had failure of fixation at the end of treatment, compared with 21.6 percent failure in those with radiographically normal or less osteoporotic bone (Fisher exact test, $p = 0.005$).

### Fragmentation

Of the eighteen patients who had simple fragmentation, only one had failure of fixation (5.5 percent). Of twenty-four patients who had complex fragmentation, fixations failed in twelve patients (50 percent) ($\chi^2$ with continuity correction, $p = 0.001$; Fig. 3).

### Preoperative Displacement

There was a significant association between preoperative displacement and failure of fixation. None of the

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### TABLE 4. The type of implants used in fixation

<table>
<thead>
<tr>
<th>Type of implant</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancellous lag screws alone</td>
<td>6</td>
</tr>
<tr>
<td>Large fragment plate and screws</td>
<td>23</td>
</tr>
<tr>
<td>Small fragment plate and screws</td>
<td>8</td>
</tr>
<tr>
<td>Combined internal and external fixation</td>
<td>5</td>
</tr>
</tbody>
</table>

### TABLE 5. Distribution of 42 tibial plateau fractures according to the Schatzker classification (30)

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of patients</th>
<th>Failure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>III</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>IV</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>VI</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>13</td>
</tr>
</tbody>
</table>

### TABLE 6. Distribution of 42 tibial plateau fractures according to the AO classification (23)

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of patients</th>
<th>Failure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>B2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>B3</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>C1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>C2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>C3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>13</td>
</tr>
</tbody>
</table>
twenty-two moderate preoperative displacements had failure of fixation, compared with thirteen failures (65 percent) in the twenty patients with severe preoperative displacement ($p < 0.001$; Fig. 3).

**Soft Tissue Injury**

A medial collateral ligament injury was identified in four patients; two lost reduction. A meniscal injury was present in five patients, two of whom had failure. Lateral collateral ligament injury was recorded in two patients, an anterior cruciate ligament injury occurred in two patients, and a posterior cruciate ligament injury occurred in two patients. None had failure of fixation.

**Compliance With Weight Bearing Instructions**

Noncompliance with weight bearing instructions was reported in ten patients (24 percent). It occurred in both young and elderly patients. There was a significant association between premature weight bearing and failure of fixation ($p < 0.05$). The two patients who discarded their walking aids against advice during the first six weeks both had failure of fixation (100 percent), both of them were older than seventy years (Fig. 5). A further eight patients commenced premature partial weight bearing during the first six weeks postoperatively; six of them lost reduction (75 percent). Of the thirty-six patients who avoided full weight bearing until after ten weeks, nine had failure of fixation (25 percent).

Gender, time to surgery, operative time, type of fixation implants, use of bone graft, and postoperative bracing had no statistically significant relationship to the rate of failure (Fig. 4).

**DISCUSSION**

This study, using a strict definition and critical analysis, reports a 31 percent rate of radiologic failure of fixation after operative treatment of tibial plateau fractures. This is higher than previously published series, which range from 1 to 18 percent. However, in these series failure of fixation was frequently not defined or addressed.

In our series we considered the failure of fixation using the same parameters that were the indication for primary fixation. There is more agreement on these measures as indicated by our ballot of experts (Table 2). The

difference in our series may be explained by a more critical examination of follow-up radiographs or as opposed to functional outcome results as the measure in other series. The relationship between radiologic loss of reduction and clinical outcome is a subject for further research.

The significant associations with loss of reduction are the variables of preoperative displacement, fracture fragmentation, age greater than sixty years, osteoporosis, and noncompliance with protection from weight bearing. The first two are arguable reflections of energy of injury or bone quality.

The high incidence (85 percent) of loss of fixation in the elderly patient is important. We found that all patients with severe graded osteoporosis had failure of fixation. Honkonen noted the difficulty in achieving a stable fixation in this group, and the risk of losing the reduction was high despite internal fixation and bone grafting (16). Schatzker et al. pointed out the difficulty in achieving rigid internal fixation in osteoporotic patients; they stated that osteoporosis affects the outcome adversely, regardless of the method of treatment (30). Schwartzman et al., in 1998 using patient self-assessment instrument as an outcome measurement, reported a high rate of unsatisfactory outcome in patients older than fifty years with an average age of 60 years. This unsatisfactory result was 72 percent of in the operative group, compared with 38 percent in the nonoperative group (31).

If this form of surgery is not capable of restoring and retaining joint anatomy, then the goals of treatment should be different from those set for younger patients. Surgery now offers an advantage over bed/chair rest with active mobilization if it achieves better long-term stability and an improved range of movement.

The severity of fragmentation and preoperative displacement also correlated with the failure of fixation, a result of either high energy injuring forces and/or osteoporosis. This is in agreement with Kennedy and Bailey who found that the magnitude of the forces and the degree of osteopenia determined the fragmentation and displacement of the fracture fragment (17).

An analysis of younger patients who had failure of fixation demonstrates a strong association with premature weight bearing. Few studies have highlighted the noncompliance with mobilization protocol as one of the reasons behind plateau collapse or varus malunion (22,25).

Moore et al. reported a high rate of loss of fracture position (average 2.7 mm); this was believed to be due to noncompliant patients who did not maintain non-weight bearing status after discharge from the hospital (22);
also, in the Raikin and Froimson study even with the use of a strong construct of an external fixator, the rate of varus malunion was 30% in the noncompliant patients (25).

However, early partial weight bearing has been advised by some authors (32,33). Scotland and Wardlaw reviewed a series of 29 patients who were treated with cast bracing with no loss of reduction. The cast brace gave good support to the leg without malalignment deformity, and the authors advised full weight bearing in a cast brace with early mobilization (32). Our study does not support their advice. Use of a hinged brace did not protect against loss of position, and commencing weight bearing against instruction, especially during the first six weeks postoperation, was associated with failure in 80%. This compared with a 25% failure in patients who started weight bearing after ten weeks ($p < 0.05$) irrespective of age. However, in our study the authors recognize the potential for inaccuracy in timing the exact start of weight bearing using a retrospective chart review of interval attendances. Based on our results, we think that weight bearing should be avoided for at least ten weeks.

**CONCLUSION**

It is logical to define the failure of fixation using the same radiologic parameters used as the indications for open reduction and internal fixation. Using these criteria the incidence of failure of fixation is higher than previously reported and very common in elderly patients. There is general agreement about the desirability for surgical anatomic restoration of the articular surface in younger patients, which generally cannot be achieved by nonoperative therapies. However, in the elderly age group the rate of failure of fixation was unacceptably high, and the benefits of restoring the anatomy of the proximal tibia should be weighed against the risks of failure and complications. In the elderly perhaps a limited goal to restore alignment and stability may be preferable. The potential of fine wire fixation for tibial plateau fracture stabilization in the elderly patient has been recently suggested (1,18). Also, there may be no advantage to surgery in patients who are unable to follow instructions regarding protected weight bearing. A high rate of failure in our study (31 percent) raises questions for further research. (a) What are the optimal fixation technique and implants to maintain reduction in osteoporotic bone? (b) What are the comparative longer-term clinical outcomes for those patients who do not maintain the anatomic reconstruction target on which the decision to operate was based? The answers to these questions will undoubtedly influence our further treatment of tibial plateau fractures.

**REFERENCES**

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