Reliability of locked plating in tibial plateau fractures with a medial component

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KEYWORDS
Proximal tibial fracture; Articular fracture; Locking plate; Tibial plateau fractures; Schatzker classification

Summary
\textbf{Background:} Tibial plateau fractures are notoriously difficult to manage, particularly when there is a medial or posteromedial component. We report a retrospective analysis of our experience with consecutive tibial plateau fractures including a medial component that were managed using a single lateral locking plate.

\textbf{Hypothesis:} Tibial plateau fractures with a medial component can be effectively managed using a single lateral locking plate.

\textbf{Materials and methods:} From January 2005 to December 2008, 20 patients (ten women and ten men, mean age 47 years) were managed for tibial plateau fractures having a medial component, including five Schatzker IV, five Schatzker V, and ten Schatzker VI. One patient had an open fracture. A single lateral anatomically contoured locking compression plate (LCP\textsuperscript{TM}) was used with or without additional isolated screws. Mobilization was started immediately after the procedure, and non-weight-bearing was maintained for at least 6 weeks.

\textbf{Results:} All patients were followed until healing. A final evaluation was available for 13 patients after a mean of 39.1 months (12–72); five patients were lost to follow-up and two died. Early revision was needed in one patient for 20° malreduction within the fracture site. We recorded one case each of deep vein thrombosis, superficial infection, knee stiffness, and spontaneously regressive common fibular nerve dysfunction. At final evaluation (n = 13), mean range of motion was 0°/2°/130° with a mean Lysholm score of 94.1 (73–100) and a mean HSS score of 93.6 (74–99). All previously employed patients returned to work at the same level after a mean of 4.5 months. Mean healing time (n = 20) was 10 weeks (6–12). Initially, articular step-offs greater than 2 mm were noted in five patients. At healing, no further displacements or aggravation of articular step-offs were recorded. The reductions remained stable over time. At final evaluation (n = 13), mean tibiofemoral mechanical angle was 179.7° (176–184) and no patients had evidence of osteoarthritis.

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Introduction

Proximal tibial fractures account for only 1.2% of all fractures in adults [1]. The standard treatment of complex articular fractures of the proximal tibia is plate fixation, which is particularly important when the medial plateau is involved [2–10]. To date, there is no consensus about the relative merits of the various available internal fixation methods, i.e., medial plate, dual plating, and nonlocking versus locking plates. Several authors have advocated a medial plate for all patients with medial tibial condyle involvement, as a means of improving resistance to axial compression [2–4]. Yoo et al. [5] and Jiang et al. [6] reported that standard dual plating provided greater mechanical strength than a single lateral locked plate. In contrast, experimental and clinical evidence reported by Mueller et al. [7], Gosling et al. [8,9], and Higgins et al. [10] established that a single lateral locked plate ensured reliable fixation. In all these studies, the main risk was secondary displacement. Single lateral plating has been advocated as a means of decreasing the risk of skin damage, ligament damage, and surgical site infection [11–20].

To assist in resolving this controversy, we hypothesised that complex articular fractures of the tibial plateau having a medial or posteromedial fragment would be effectively stabilised using a single lateral anatomically contoured locked plate. Our main evaluation criterion was radiological stability from the immediate postoperative period to healing. Our data came from a retrospective review of 20 consecutive patients with complex proximal tibial fractures managed using a single lateral locked LCP™ plate (Synthes®, Etupes, France).

Materials and methods

We retrospectively reviewed the 20 consecutive patients seen at our institution between January 2005 and December 2008 for isolated traumatic fractures of the tibial plateau with a medial component and treated using a single lateral anatomically contoured locked plate (LCP™, Synthes®, Etupes, France). There were ten men and ten women, with a mean age of 47 years (range, 17–85). The fractures were classified according to Schatzker [21] and the only open fracture was assessed according to Gustilo [22]. Of the 20 patients, 11 were employed and 11 had sustained high-energy injuries. Table 1 reports the main epidemiological data.

For surgery, the patient was supine on a standard operating table. A tourniquet was used in 13 patients. A single standard lateral incision with inframeniscal arthroscopy was performed in all 20 patients. In two patients, medial parapatellar arthroscopy was required to stabilize the intercondylar eminence (Fig. 1). After elevation of depressed fragments, complementary screws were required in eight patients (Fig. 2), to secure the avulsed anterior tibial tuberosity in one patient, laterally in five patients, and laterally and medially in two patients. Medial screws were inserted percutaneously. An autologous bone graft from the iliac crest was used in three patients. The plates were secured by placing locking screws in the epiphyseal/metaphyseal and diaphyseal positions. Mean operating time was 105 min (range, 80–150 min; median, 110 min). Non-weight-bearing was maintained for at least 6 weeks. Passive mobilization was started immediately after surgery using a continuous passive motion machine in the 0°–90° range.

We conducted a retrospective review. The imaging studies obtained at healing and at the final evaluation were compared to those obtained immediately after surgery. Pan-gonometry was performed at the last evaluation. As with knee replacement surgery, malalignment was defined as a greater than 5° overall deviation versus 180°. Articular surface step-offs were considered abnormal if they exceeded 2 mm [2–10]. Healing was defined as continuity of both cortices on the anteroposterior and lateral views. The clinical evaluation parameters were range of motion (ROM) and the Lysholm [23] and HSS [24] scores at the final evaluation. Return to work was recorded.

Results

Table 2 reports the main outcomes at healing and final evaluation. Follow-up data were obtained in all patients until healing was complete, allowing evaluations in all 20 patients of the healing time and, even more importantly, of construct stability. Construct stability was the primary criterion for evaluating our hypothesis. Only 13 patients underwent a final evaluation, after a mean of 38.1 months (range, 12–66; median, 36 months). Of the remaining seven patients, two had died and five were lost to follow-up.

We recorded four complications: deep vein thrombosis, superficial Staphylococcus aureus infection weeks postoperatively, palsy of the common fibular nerve with spontaneous recovery within 6 weeks, and knee stiffness requiring arthrolysis 18 months postoperatively (ROM, 0°/15°/80° before and 0°/5°/130° after arthrolysis). In another patient, early revision was required on postoperative day 10 for malreduction with 20° of flexion in the diaphyseal portion of a Schatzker VI fracture.

Of the 20 patients, nine reported discomfort due to the hardware. Among them, seven underwent hardware
removal, after a mean of 18 months (range, 5–32; median, 18 months). Hardware removal was followed by an infection in one patient.

At the final evaluation, mean ROM was 0°/2°/130°. Four patients had fixed knee flexion with a mean of 6.2° (5–10). The mean Lysholm score was 94.1 (73–100; median, 98) and the mean HSS score was 93.6 (74–99; median, 97). The 11 patients who had been employed at the time of the injury were able to return to the same job, after a mean of 4.5 months (1–10; median; 4 months).

Healing was achieved in all 20 patients, after a mean of 10 weeks (6–16; median, 10 weeks). In the immediate postoperative period, five patients had an articular step-off. Comparisons of the imaging studies immediately after surgery and at healing disclosed no further malreduction and no secondary displacement. Pamongraphy in the 13 patients who underwent a final evaluation showed a mechanical axis mean of 179.7° (176–184; median, 180°), compared to 179° (176–183; median, 180°) contralaterally. None of the 13 patients had deviations in excess of 5° and none had evidence of post-traumatic osteoarthritis.

**Discussion**

Limitations of our study include the heterogeneous patient population, surgery by several different senior surgeons, and use of a non-standardised surgical technique. However, the availability of follow-up data until healing in all patients allowed us to evaluate construct stability over time. The absence of secondary displacement and of worsening of articular step-offs establishes the effectiveness of a single lateral locked plate in this indication.

The treatment of complex proximal tibial fractures remains debated in the literature, and there is no consensus on the relative merits of single plate versus dual plate constructs or nonlocking versus locking screws. The experimental and clinical results published to date are conflicting. Experimental studies by Wu and Tai [2], Ratcliffe et al. [3], and Zeng et al., [4] support the use of a medial buttress when the fracture has a medial component. Yoo et al. [5] advocated dual plating in highly complex fractures. They used composite tibias to compare a lateral 3.5 mm compression plate (CP), dual plating with a CP and a posteromedial dynamic compression plate (CP-DCP), dual plating with a CP and a posteromedial 1/3 tubular plate, a single lateral locking plate, and the Less Invasive Stabilisation System (LISS). Tolerated axial loads were highest with the CP + 1/3 tubular plate construct [5]. Jiang et al. [6] reported identical experimental results. In contrast, dual plating and lateral single locked plating produced similar performances under experimental conditions in studies by Mueller et al. [7], Gosling et al. [8], and Higgins et al. [10]. Recent experimental work has clarified the use of locked plates in complex proximal tibial fractures. Estes et al. [25] found no difference between all-locked and combination locked/nonlocked constructs during axial loading. Cullen et al. [26] reported that polyaxial locking plates with axial screws provided the greatest stiffness and loads to failure. Lindeque and Baldini [27] compared three locking systems and found that Synthes® and DePuy® were associated with greater loads to subsidence compared to Zimmer® and that DePuy® gave the greatest load to failure. These published data support the effectiveness of a single lateral locking plate. Our imaging study findings support the experimental results by showing no secondary displacement or worsening of initial malreductions. The stability of the constructs over time confirms our working hypothesis.

**Table 1 Main epidemiological data in the 20 patients.**

<table>
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<tr>
<th>Patient #</th>
<th>Age, years</th>
<th>Sex</th>
<th>Occupation</th>
<th>Type of accident</th>
<th>Schatzker Type [21]</th>
<th>Immediate complications</th>
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<td>Factory worker</td>
<td>MVA</td>
<td>V</td>
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</table>

M: male; F: female; MVA: motor vehicle accident.
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<tr>
<th>Pt #</th>
<th>FU (mo)</th>
<th>Postoperative complications</th>
<th>Step-off &gt;2 mm</th>
<th>Healing time (weeks)</th>
<th>ROM (°)</th>
<th>Lysholm score [23]</th>
<th>HSS score [24]</th>
<th>Return to work (mo)</th>
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<td>LTFU</td>
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<td>4</td>
<td>8 (LTFU)</td>
<td>Revision for 20° flexion malreduction, transient palsy of common fibular nerve</td>
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<td>LTFU</td>
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<tr>
<td>5</td>
<td>22 (LTFU)</td>
<td>Stiffness: 0/15/80, arthrolysis after 18 mo</td>
<td>16</td>
<td>0/5/130 at last FU</td>
<td>LTFU</td>
<td>LTFU</td>
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<tr>
<td>6</td>
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<td>98</td>
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Pt: patient; FU: follow-up; mo: months; ROM: range of motion; LTFU: lost to follow-up; D: died.
Locked plating in Schatzker IV/V/VI tibial plateau fractures

In a clinical study by Barei et al. [28], dual plate fixation via conventional surgical approaches was reliable and produced satisfactory clinical outcomes. According to de la Caffinière [29], a semi-circular anterior plate was associated with good clinical outcomes and stable radiological results. Minimally invasive approaches have been developed to minimize skin complications and infections. Using minimally invasive percutaneous dual plating, Oh et al. [30] obtained 21 excellent clinical outcomes among 23 patients, with malalignment in 9.5% cases. These authors emphasized the absence of iatrogenic complications with this minimally invasive surgery. We have no experience with minimally invasive surgery for complex proximal tibial fractures and we remain convinced that directly controlled reduction is preferable. In the literature, a single clinical study (n = 84) compared conventional dual plating to a single lateral locked plate via a minimally invasive approach (LISS) [31]. No statistically significant differences were found for loss-of-reduction, hardware failure, infection rates, healing rates, or the functional HSS score. However, imaging studies showed significantly greater malalignment with the LISS system, which was probably ascribable to the minimally invasive approach. The authors concluded that the LISS was effective and was an alternative treatment option to dual plating but that conventional-incision dual plating remained the standard of care [31]. Ten recent studies report outcomes after locked plating of complex proximal tibial fractures [11–20]. Malreduction rates ranged from 0% to 23% and loss-of-reduction rates from 0% to 14%. We recorded no cases of secondary displacement but found an articular step-off rate of 25%. All the authors concluded that a lateral locked plate is appropriate for complex proximal tibial fractures and provides both stable radiological results over time and a good level of functional recovery. Our radio-clinical data confirm this conclusion and emphasize the need for high-quality initial reduction. The ROM and functional score results in our study are highly satisfactory, and all employed patients were able to return to their previous job. Thus, in our experience, articular step-offs do not seem to impact the radio-clinical results in the short-term.

Minimally invasive surgery is possible but is highly demanding and technically challenging in patients with tibial

Figure 1  Schatzker V fracture of the right tibia. A: anteroposterior and lateral preoperative radiographs showing a Segond fracture; B: preoperative computed tomography showing lateral depression and tibial spine avulsion; C: radiographs at healing. Note the additional screws maintaining the lateral depressed fragment and the avulsed fragment.
Figure 2  Schatzker V fracture of the right tibia. A: anteroposterior and lateral preoperative radiographs; B: preoperative computed tomography showing the medial injury; C: radiographs at healing. Note the additional anteroposterior screw used to secure the medial fragment.
plateau fractures involving articular fracture [32]. Considerable experience is required. However, minimally invasive surgery has been advocated for patients with soft tissue damage [11–20]. Medial fragment fixation may require additional screws to stabilize the fracture line located chiefly in the coronal plane. This is the limit of the monoaxial configuration of locking screws. Most authors have emphasized this point [11–20].

**Conclusion**

A single lateral locking plate ensured good outcomes in patients with proximal articular fractures of the tibia having a medial component. The imaging study results were stable over time and the short-term clinical outcomes were satisfactory, confirming our working hypothesis. Importantly, the monoaxial configuration of locking screws requires the insertion of additional screws to provide strong fixation in patients with coronal medial fracture lines.

**Disclosure of interest**


**References**