ABSTRACT

Purpose. To review short-term outcomes of proximal femoral locking compression plate (PF-LCP) fixation for proximal femoral fractures in terms of postoperative complications and failure rates.

Methods. Medical records of 21 men and 5 women aged 22 to 85 (mean, 49.7) years who underwent internal fixation with the PF-LCP for proximal femoral fractures were reviewed. Younger patients (mean age, 38.7 years) were more commonly involved in high-energy trauma with multiple musculoskeletal injuries, whereas older patients (mean age, 67.7 years) were more commonly involved in low-energy trauma. Fractures were classified into: multi-fragmentary pertrochanteric fractures (n=13), transtrochanteric fractures (n=6), and subtrochanteric/proximal diaphyseal fractures (n=7).

Results. Patients were followed up for a mean of 14.7 months. Seven patients developed complications including loosening of locking screws (n=4), delayed union (n=2), and infection (n=1); 4 of them required additional surgeries.

Conclusion. The PF-LCP is appropriate for complex proximal femoral fractures with poor bone quality, revision surgeries, and multi-fragmentary subtrochanteric/proximal diaphyseal fractures. For intertrochanteric fractures, the sliding hip screw system should be used to avoid failure.

Key words: bone plates; complications; equipment failure analysis; femoral neck fractures

INTRODUCTION

The treatment of proximal femoral fractures is challenging owing to the high risk of complications. 1 The 4.5/5.0 mm proximal femoral locking compression plate (PF-LCP; Synthes, West Chester [PA], USA) is a limited-contact, angular, stable construct designed specifically for fractures in the proximal femoral region. 2

Unlike conventional compression plate, the screw head ‘locks’ into the PF-LCP, thereby creating an angular, stable construct. 3 Thus, the PF-LCP does not
fail at the screw-bone interface, and provides strong anchor in osteoporotic bones. The multiple locking screw holes of the PF-LCP provide various options to tackle complex fracture patterns. The PF-LCP also functions as an internalised external fixator, and close plate-to-bone contact is not needed. This minimises pressure on the periosteum, enabling more biological healing. Although conventional plating systems (such as the 95°-angled blade plate) can achieve angular stable fixations, they require a wide exposure and precise plate positioning, with little margin for error. The locking plate technology couple with a built-in metaphyseal contour enables fixation using the minimally invasive plate osteosynthesis (MIPO) technique.

This study reviewed short-term outcomes of PF-LCP fixation for proximal femoral fractures in terms of postoperative complications and failure rates.

MATERIALS AND METHODS

Medical records of 21 men and 5 women aged 22 to 85 (mean, 49.7) years who underwent internal fixation with the PF-LCP for proximal femoral fractures between May 2008 and April 2009 were reviewed (Table 1).

There was a bimodal distribution in patient age corresponding to the mechanisms of injury. Younger patients (mean age, 38.7 years) were more commonly involved in high-energy trauma such as motor vehicular accidents (n=10), falls from a height (n=2), crush injuries (n=3), and others (n=1); 70.6% of them sustained multiple musculoskeletal injuries. Older patients (mean age, 67.7 years) were more commonly involved in low-energy trauma such as falls during walking (n=10); only 10% had multiple musculoskeletal injuries.

According to the AO Foundation/Orthopaedic Trauma Association classification, fractures were classified into: multi-fragmentary pertrochanteric fractures (type 31A2) [n=13], transtrochanteric fractures (type 31A3) [n=6], and subtrochanteric/proximal diaphyseal fractures (type 32A/B/C) [n=7]. PF-LCP was not used for 2-part intertrochanteric fractures (type 31A1).

Both open and MIPO techniques were used. For the former, the PF-LCP was inserted through a direct lateral incision on the hip, which was centred over the greater trochanter and the lateral aspect of the femur shaft. Using an image intensifier, the fracture was reduced and provisionally held in position with Kirschner wires and reduction forceps. For pertrochanteric fractures, a partially threaded cancellous screw was inserted into the proximal 7.3-mm hole to achieve better fracture compression. This screw was subsequently replaced with a locking screw after installing the rest of the locking screws. Depending on the fracture configuration, the distal end of the plate was secured with a mixture of locking and cortical screws.

For the MIPO technique, indirect reduction was achieved with the aid of a traction table. A small incision was made over the greater trochanter, and a sub-muscular tunnel was created using a Cobb elevator. An appropriately sized PF-LCP was then slid into position and was locked using a mixture of locking and cortical screws after reduction.

Normally distributed data were analysed using the one-way analysis of variance. A p value of <0.05 was considered statistically significant.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multi-fragmentary pertrochanteric fractures (n=13)</th>
<th>Transtrochanteric fractures (n=6)</th>
<th>Subtrochanteric/proximal diaphyseal fractures (n=7)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>51.5</td>
<td>49.8</td>
<td>45.7</td>
<td>0.823</td>
</tr>
<tr>
<td>No. of men:women</td>
<td>11:2</td>
<td>5:1</td>
<td>5:2</td>
<td></td>
</tr>
<tr>
<td>Fracture type (AO classification)</td>
<td>31A2.1 (n=3)</td>
<td>31A3.1 (n=1)</td>
<td>32A1-3.1 (n=3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31A2.2 (n=5)</td>
<td>31A3.2 (n=0)</td>
<td>32B1-3.1 (n=1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31A2.3 (n=5)</td>
<td>31A3.3 (n=5)</td>
<td>32C1.1-3 (n=3)</td>
<td></td>
</tr>
<tr>
<td>Mean operating time (minutes)</td>
<td>151.6</td>
<td>116.5</td>
<td>163.2</td>
<td>0.484</td>
</tr>
<tr>
<td>Mean time to fracture union (months)</td>
<td>9.8</td>
<td>9.4</td>
<td>11.0</td>
<td>0.852</td>
</tr>
<tr>
<td>Mean blood loss (g/dl)</td>
<td>3.4</td>
<td>0.8</td>
<td>4.6</td>
<td>0.009</td>
</tr>
<tr>
<td>Mean±SD SF36 physical component score</td>
<td>40.5±8.0</td>
<td>40.2±6.6</td>
<td>41.8±8.1</td>
<td>0.951</td>
</tr>
<tr>
<td>Mean±SD SF36 mental component score</td>
<td>44.9±14.5</td>
<td>43.4±13.6</td>
<td>50.5±9.1</td>
<td>0.711</td>
</tr>
<tr>
<td>Mean±SD Harris Hip Score</td>
<td>69.1±17.9</td>
<td>80.1±14.3</td>
<td>80.2±15.9</td>
<td>0.411</td>
</tr>
</tbody>
</table>

Table 1
Comparison of patient characteristics based on 3 fracture patterns
RESULTS

Patients were followed up for a mean of 14.7 months. Seven patients had complications including loosening of locking screws (n=4), delayed union (n=2), and deep infection (n=1) [Table 2 and Figs. 1 to 7]; 4 of them required additional surgeries. Loosening of locking screws occurred mainly in patients with multiple fragmentary pertrochanteric fractures and was possibly due to the medial calcar fracture and inadequate reduction. Delayed union occurred in patients with multi-fragmentary subtrochanteric/

<table>
<thead>
<tr>
<th>Sex/age (years)</th>
<th>Fracture side</th>
<th>Fracture type (AO classification)</th>
<th>Mechanism of injury</th>
<th>Comorbidities</th>
<th>Complication</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/34 Right</td>
<td>31A2.2</td>
<td>Road traffic accident (passenger)</td>
<td>None</td>
<td>Loosening of proximal locking screw with loss of reduction</td>
<td>Revision with non-hook PF-LCP and autologous bone grafting (harvested from the ipsilateral tibia)</td>
<td></td>
</tr>
<tr>
<td>M/85 Left</td>
<td>31A3.3</td>
<td>Fall while walking</td>
<td>None</td>
<td>Loosening of distal locking screw with slight loss of reduction</td>
<td>Conservative management</td>
<td></td>
</tr>
<tr>
<td>M/62 Left</td>
<td>31A2.1 + femoral shaft fracture 31A2.2</td>
<td>Road traffic accident (motorcyclist)</td>
<td>None</td>
<td>Loosening of kickstand screw</td>
<td>Conservative management until fracture union, followed by removal of the kickstand screw that causes irritation</td>
<td></td>
</tr>
<tr>
<td>M/80 Right</td>
<td>31A2.2</td>
<td>Fall while walking</td>
<td>Diabetes mellitus, hypertension</td>
<td>Loosening of proximal locking screw</td>
<td>Conservative management. Patient lost to follow-up</td>
<td></td>
</tr>
<tr>
<td>M/43 Right</td>
<td>31A2.3</td>
<td>Road traffic accident (motorcyclist)</td>
<td>Dyslipidaemia</td>
<td>Delayed union</td>
<td>Autologous bone grafting (harvested from the ipsilateral tibia) with the PF-LCP in situ</td>
<td></td>
</tr>
<tr>
<td>M/50 Left</td>
<td>32C2.2</td>
<td>Road traffic accident (pedestrian)</td>
<td>None</td>
<td>Delayed union</td>
<td>Autologous bone grafting (harvested from the ipsilateral tibia) with the PF-LCP in situ</td>
<td></td>
</tr>
<tr>
<td>F/57 Left</td>
<td>32A3.1</td>
<td>Fall while walking</td>
<td>Hypertension, end stage renal failure, hyperlipidaemia, liver cirrhosis, ischaemic heart disease</td>
<td>Deep infection</td>
<td>Removal of implant with multiple debridements, followed by fixation with a proximal femoral nail antirotation coated with antibiotics impregnated cement</td>
<td></td>
</tr>
</tbody>
</table>

Table 2

Complications after fixation with proximal femoral locking compression plate (PF-LCP) for proximal femoral fractures

Figure 1 (a) A pertrochanteric fracture (AO type 31A2.2) is fixed with the hook proximal femoral locking compression plate (PF-LCP). (b) Varus collapse with loss of reduction is revised with a non-hook PF-LCP and achieves union subsequently.
proximal diaphyseal fractures after high-energy trauma who underwent open rather than MIPO technique. The causes of delayed union were multifactorial, rather than the implant factor alone. The open technique used may have led to periosteal stripping and devascularisation of bone fragments. Furthermore, bone grafting should have performed initially.

**DISCUSSION**

The PF-LCP was reported to be the strongest construct for vertically orientated femoral neck fractures among 4 different fixation techniques. The PF-LCP with the ‘kickstand’ screw was reported to have similar biomechanical properties as the 95º-angled blade plate. One study reported that the PF-LCP fixation achieved a union rate of 100% in 110 patients with pertrochanteric femoral fractures at the one-year follow-up. Nonetheless, screw breakage after PF-LCP fixation is a complication in pertrochanteric fractures with missing posteromedial corners, which leads to high axial bending forces around the fracture site with eventual varus collapse of the fracture and screw breakage. Other reported complications include loss of fixation with and without screw breakage and plate breakage; the failure rate was independent of the surgeon’s experience. In our study, PF-LCP fixation had a complication rate of 27%, with loosening of proximal locking screws being the most common.

Sliding hip screw system and proximal femoral nail antirotation system enable controlled impaction of the intertrochanteric fracture (AO type 31A1/A2) fragments. Whereas the PF-LCP system locks the fracture in position without controlled collapse. Fractures involving the medial calcar, or fractures that are inadequately reduced result in high varus strains at the fracture-implant interface. This leads to progressive loosening of the locking screws and varus collapse of the fracture with eventual construct

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**Figure 2** (a) A reverse oblique fracture (AO type 31-A3.3) is fixed with the proximal femoral locking compression plate. (b) Varus collapse of the fracture causes one of the locked screws to back out, but union is achieved without further intervention.

**Figure 3** (a) A pertrochanteric fracture (AO type 31A2.2) and a femoral shaft fracture are fixed with a long proximal femoral locking compression plate. (b) Three months later, varus displacement of the fracture causes one of the locked screws to back out, but union is achieved without further intervention. The backout screw causes irritation and needs to be removed.
Figure 4  (a) A pertrochanteric fracture (AO type 31A2.3) is fixed with the proximal femoral locking compression plate. (b) After 2 months, autologous bone grafting is performed for the delayed union and eventually union is achieved.

Figure 5 (a) A subtrochanteric fracture (AO type 32C2.2) is fixed with the proximal femoral locking compression plate. (b) Autologous bone grafting is performed for delayed union and eventually union is achieved.

Figure 6 (a) A proximal diaphyseal fracture (AO type 32A3) is fixed with the proximal femoral locking compression plate. (b) Two months later, the implant is removed owing to deep infection with loosening of the implant. (c) A proximal femoral nail antirotation coated with antibiotic-impregnated cement is inserted. (d) The spiral blade of the nail is removed, as it backs out and causes hip irritation.
failure, particularly in the hook PF-LCP fixation, where only one 7.3-mm locking screw is used in the proximal metaphysis (as opposed to 2 screws in the non-hook PF-LCP).

Based on our series, the indication for use of PF-LCP is narrower than that suggested in the PF-LCP operative technique guide. Intertrochanteric fractures (AO type 31A1/A2) should not be treated with the PF-LCP. Instead, a sliding hip screw or similar device should be used. If the PF-LCP is used, it is important to achieve anatomic reduction, as the PF-LCP does not allow controlled collapsed of the fracture fragments.

PF-LCP fixation is appropriate for complex proximal femoral fracture fixation (e.g. osteoporotic bones, complex multi-fragmentary subtrochanteric fractures, and revision surgeries). Multiple locking screws increase bony purchase of the femoral neck and are especially advantageous in fractures with bone loss. The key to successful outcomes in PF-LCP fixation for proximal femoral fractures lies in good preoperative planning. Preoperative templating enables reduction planning and selection of an appropriate implant (Fig. 8). If the PF-LCP is used, the fracture must be adequately reduced and all proximal femoral locking screws (including the ‘kickstand’ screw) should be inserted to increase the mechanical strength of the construct (Fig. 9).

This study had several limitations. The surgical indication for the PF-LCP and the choice of MIPO versus open technique were not adequately documented. The sample size was small, especially within each fracture group.

CONCLUSION

The PF-LCP is appropriate for complex proximal femoral fractures with poor bone quality, revision surgeries, and multi-fragmentary subtrochanteric/
proximal diaphyseal fractures. For intertrochanteric fractures (AO type 31A1/A2), the sliding hip screw system should be used to avoid failure.

**DISCLOSURE**

No conflicts of interest were declared by the authors.

**REFERENCES**