Treatment of distal humerus fractures with LCP DHP™ locking plates in patients older than 65 years

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Accepted: 30 December 2012

Summary

Introduction: Fractures of the distal humerus are often complex and therefore challenging to treat. In elderly patients with decreased bone strength due to osteoporosis, strong fixation is crucial to allow resuming early motion that guarantees a good functional outcome as well as minimising mechanical complications. Locked implants meet these requirements. Here, we report outcomes in a uniform series of patients older than 65 years with distal humerus fractures managed with LCP DHP® (Synthes) fixation. Our objective was to evaluate the efficacy and limitations of this technique.

Hypothesis: LCP DHP provides strong fixation of osteoporotic bone and leads to good clinical and radiological outcomes.

Materials and methods: We retrospectively studied 46 consecutive patients (2004–2010) with a mean age of 80 years including 15 with extra-articular and 31 with articular distal humerus fractures. At presentation, 11 complications were noted in nine patients (compound fractures and trauma-related nerve injuries). The transolecranon approach was used in 31 patients. Mean duration of immobilisation was 2.7 weeks in 33 patients.

Results: Forty-three patients were re-evaluated after a mean follow-up of 25 months (range, 10–64 months); two patients died and one was lost to follow-up. Flexion was 127° and loss of extension was 23°, producing an average range of motion of 104°. Functional recovery was highly satisfactory with a Mayo Clinic Performance Score of 87 (70–100) and 95% of good and very good results. Postoperative complications consisted of infection (n = 3), metaphyseal non-union (n = 2), ulnar nerve injury (n = 6), transient radial nerve palsy (n = 1), and peri-articular ossification (n = 4). Compound fracture and worse AO fracture type were associated with worse functional outcomes.

Discussion: Despite the high complication rate, functional recovery was similar to that reported in previous case series, including after arthroplasty. Furthermore, the rate of mechanical complications was lower. Thus, our working hypothesis was confirmed.

Level of evidence: Level IV retrospective non-comparative study.

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Introduction

Fractures of the distal humerus are relatively rare (<2%) and occur in an increasingly elderly population [1]. Challenges to internal fixation in elderly patients include fracture complexity and poor bone quality. These challenges mandate special attention to surgical indications and implant selection [2]. The technical difficulties raised by these fractures and the risk of insecure fixation have led several authors to advocate first-line arthroplasty in carefully selected patients [3–8].

In elderly patients, internal fixation must be extremely stable to minimise the risk of non-union [9,10] and to allow early elbow mobilisation, which is crucial to good functional recovery. Locking plate systems have been proven effective in maintaining fracture reduction and producing stable constructs in fragile bone [11]. Thus, these systems seem to meet requirements for treating elderly patients.

In this retrospective study, we report our experience with distal humerus fracture fixation in consecutive patients older than 65 years using an anatomic plate system with angular stability, LCP DHP® (Synthes, Etupes, France). To our knowledge, ours is the largest published series focusing specifically on elderly patients. Our objective was to assess the efficacy and limitations of LCP DHP® fixation in patients older than 65 years. Our working hypothesis was that LCP DHP® fixation improved fixation stability, healing, and functional outcomes.

Material and methods

Patients

We retrospectively studied consecutive patients older than 65 years of age at the time of a distal humerus fracture for which the primary treatment was locked compression plate fixation using LCP DHP® plates (Synthes) from early 2004 to late 2010. We excluded patients with missing data, patients managed with other types of implants (n = 50) or arthroplasty (n = 21), patients with pathological fractures, and patients receiving LCP DHP® fixation after failure of previous internal fixation.

We identified 46 patients (31 women and 15 men) with a mean age of 80.3 years (range, 66.1–97.6 years). The dominant side was affected in 22 patients. The fracture occurred after a fall from standing height in 36 patients and after a high-energy trauma (pedestrian-light motor vehicle collision or fall from height or while bicycling) in the remaining 10 patients. At presentation, 11 complications were recorded, including a skin breach in eight patients (six Gustilo type I and two Gustilo type II [12]), radial nerve injury in one patient, and ulnar nerve injury in two patients. No patients had blood-vessel injury or compartment syndrome.

Radiographs showed the following distribution in the AO/OTA classification system: type A, n = 15 (13 A2 and two A3); type B, n = 6 (two B1, three B2, and one B3); and type C, n = 25 (two C1, 11 C2, and 12 C3) [13].

In eight patients, another lesion was present in the same upper limb: radial head fracture managed functionally in two patients, distal radius fracture managed with volar plate fixation during the same procedure in one patient, fracture of the surgical humeral neck managed by nailing in one patient, fracture of the clavicle managed by figure-of-8 splitting in one patient, olecranon fracture in one patient, dislocation of the interphalangeal joint of the thumb reduced on an emergency basis in one patient, and 5th metacarpal fracture managed by conservative orthopaedic treatment in one patient. The elbow fracture was isolated in 16 patients. The other concomitant lesions affected the axial skeleton or lower limbs, in 11 patients: five patients had proximal femoral fractures managed by cervico-diaphyseal nailing or hip arthroplasty, one had devastating bilateral leg fractures with an MESS score of 8 requiring bilateral amputation, two had anterior pubic rami fractures and one an iliac wing fracture managed functionally, one had a fracture of the second cervical vertebra requiring screw fixation, and one had flail chest requiring internal fixation.

In 45 patients, internal fixation was the first-line treatment. The remaining patient was a 97-year-old man with displacement of a supra-condylar fracture after 1 month of plaster cast immobilisation.

Surgical technique

Five senior and 10 junior surgeons performed the surgical procedures. Mean time from trauma to surgery was 2.5 days (range, 0–30 days; median, 1 day) and mean operative time was 134 minutes (range, 60–240 minutes; median, 130 minutes). A pneumatic tourniquet was used in 23 patients, for a mean duration of 106 minutes (range, 60–135 minutes; median, 117 minutes).

Various approaches were used depending chiefly on fracture complexity and on the risk of conversion to total elbow arthroplasty. The transolecranon approach was used in 31 patients (including one with a fractured olecranon): seven with supra-condylar fractures, two with B2 unicondylar fractures, one with B3 bicondylar fractures, and 21 with supra-inter-condylar fractures; fixation was by pinning and tension band wiring in 29 cases, screws and tension band wiring in four cases, and screws only in one case. A paratendinous approach was used in nine patients, including four with supra-condylar fractures, two with unicondylar fractures, and three with supra-inter-condylar fractures. The Bryan-Morrey approach [14] was chosen in one patient with a distal supra-condylar fracture (type A2) and in one patient with a comminuted supra-inter-condylar fracture (type C3), both of whom were at high risk for intraoperative conversion to arthroplasty. A lateral approach was used in one patient with a lateral condyle fracture (type B2) and in two patients with supra-condylar fractures (type A2). Finally, one patient with a supra-condylar fracture extending to the diaphysis was managed with theterticeps-splitting approach.

Ulnar nerve neurolysis was performed routinely in patients managed via a posterior approach. In 10 patients, the ulnar nerve was transposed, in the absence of clearly documented reasons. Among these patients, only one reported persistent paresthesia. In patients managed via a lateral approach, the radial nerve was identified but neurolysis was not performed.
Internal fixation was achieved using a single angular-stability plate in eight patients (three medial, two lateral, and three dorsolateral plates), most of whom had unicondylar fractures. Two plates were used in the remaining 38 patients (33 orthogonal constructs, three parallel constructs with the plates on the posterior aspect of the humerus, and two parallel constructs with one plate on the medial aspect and the other on the lateral aspect of the humerus); in six patients, the two plates had the same length. In three patients, bony defects caused by impaction required filling with autologous bone grafts.

The postoperative management was tailored to the intraoperative findings. Immobilisation was more often used in patients with type C fractures and fragile bone (68% of type C fractures versus 52% of type A and B fractures). In 14 patients, no restrictions were advised on the rehabilitation programme, which consisted in active movements below the pain threshold, with a simple flexion splint to minimise pain during the first 2 weeks. In seven patients, immobilisation was used between passive mobilisation sessions, for a mean duration of 4.5 weeks (range, 2–6 weeks; median, 3 weeks). The remaining 25 patients had their elbow immobilised for a mean of 3.0 weeks (range, 2–8 weeks; median, 3 weeks), after which they were free to perform active movements below the pain threshold and received passive mobilisation sessions from a physical therapist.

Given the absence of proven efficacy and the risk of adverse events in elderly patients, routine anti-inflammatory drug therapy to prevent peri-articular ossification was not administered.

**Evaluation of outcomes**

An independent observer performed clinical and radiographic evaluations. The clinical examination served to collect data on functional recovery, pain, range of motion, and possible residual neurological and vascular abnormalities. Flexor and extensor muscle strength was measured using a dynamometer, comparatively to the healthy side. The Mayo Elbow Performance Score (MEPS) was chosen to evaluate functional recovery [15] (Box 1). Standard antero-posterior and lateral radiographs were obtained to assess bone healing and to look for evidence of mechanical complications.

**Statistical analysis**

All statistical analyses were performed using SAS 9.0 for PC (SAS Institute, Cary, NC, USA) and SPSS v20.0 for Mac (IBM, SPSS Statistics, Armonk, NY, USA). Categorical variables were compared using the chi-square test or the Fisher exact test, as appropriate. For comparisons of continuous variables, we used the non-parametric Mann-Whitney test, or the global Kruskal-Wallis test when there were more than two categories. All tests were 2-tailed and P values lower than 0.05 were considered significant.

<table>
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<tr>
<th>Box 1: Mayo Elbow Performance Score.</th>
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<td>Function</td>
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<td>Pain</td>
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<td>Motion</td>
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<tr>
<td>Total</td>
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</table>

**Results**

**Patient population**

At re-evaluation, one patient was lost to follow-up and two others had died, leaving 43 patients who were re-evaluated after a mean of 25 months (range, 10–64 months; median, 25 months).

Mean total hospital stay length was 10.6 days (range, 5–31 days; median, 10 days) and mean hospital stay length after surgery was 7.8 days (range, 2–26 days; median, 7 days).

**Functional outcomes**

Of the 43 patients, 31 (73%) were free of pain, 10 (23%) reported mild pain chiefly dependent on the weather, and two (4%) reported moderate pain of variable intensity occurring mainly during brief but heavy use of the elbow.

Mean flexion was 127° (range, 100–140°; median, 130°). Mean loss of extension was 23° (range, 0–50°; median, 20°) producing a mean motion arc 104° (range, 70–140°; median, 105°). In 22 patients, the “useful” arc of motion was 0–30–130° or more than 100° of elbow flexion—extension [16]. Median flexion was 138° (range, 115–140°) in type A fractures, 125° (range, 100–130°) in type B fractures, and 125° (range, 100–140°) in type C fractures (P=0.031); corresponding median motion arcs were 110° (range, 75–140°), 95° (range, 80–125°), and 98° (range, 70–130°) (P=0.046). Internal fixation via the transeolecranon approach was associated with 30° of average fixed flexion (range, 0–50°) versus 10° (range, 0–40°) for the other approaches (P=0.001),
and with a motion arc of 100° (70—130°) versus 120° (range, 75—140°) \( (P=0.015) \); however, it should be borne in mind that the transolecranon approach was used chiefly in patients with type 4 fractures. In compound fractures, median flexion was 120° (range, 100—140°) versus 130° (100—140°) in closed fractures \( (P=0.050) \); the motion arc was not significantly different between these two groups. Range of extension was significantly greater after fixation with a single plate (−10°; range, −30° to 0°) than with two plates (−20°; range, −50° to 0°) \( (P=0.041) \). Pronation—supination was nearly normal (mean, 143° range, 80—160°; median, 150°). The mean MEPS was 87/100 (70—100; median, 87.5), with 95% of good or excellent results and no poor results. The mean MEPS was significantly higher in the group with type B fractures (95/100; range, 90—100) than in the groups with type A fractures (85; range, 70—95) and type C fractures (85; range, 70—95) \( (P=0.023) \).

All patients were able to return to their previous activities. Compound fracture predicted greater flexion limitation with no significant effect on the functional score. Range-of-motion limitation was greater in the groups with unicondylar or supra-inter-condylar fractures compared to the group with supra-condylar fractures, but functional scores were significantly higher in the group with unicondylar fractures than in the groups with type A or C fractures. Furthermore, the number of plates used for internal fixation affected the degree of elbow extension recovery; however, a confounding factor is the difference in fracture-type distribution between the two groups. Neither the presence of another lesion in the same upper limb nor the duration of immobilisation significantly affected the final functional score. Use of the transolecranon approach seemed associated with poorer outcomes, particularly regarding the range of extension and the motion arc, although no impact was noted on the MEPS.

**Radiographic findings**

Articular reduction quality was considered good in all patients, with a step-off smaller than 2 mm [9] in three patients. No patients had epiphyseal-metaphyseal malunion or epiphyseal non-union (Fig. 1). Healing was achieved in 95% of patients, and mean time to healing was 8 weeks (range, 6—15) in 41 patients. Metaphyseal non-union was diagnosed in two patients 10 and 12 months after surgery, respectively (Fig. 2). Non-union after olecranon osteotomy followed by pinning and tension band wiring was noted in two patients. Functional outcomes in the four patients with non-union were not poorer than in the other patients \( (P>0.05) \). Revision surgery was not performed, as all four patients were older than 80 years of age and reported few symptoms. Healing was achieved in both patients with olecranon fractures.

**Complications**

We observed a high complication rate of 14/43 patients, i.e., 33%. Complications included early surgical-site infection by community-acquired *Staphylococcus aureus* in two patients, both of whom had favourable outcomes after surgical lavage and appropriate antibiotic therapy. This complication had no adverse effect on the MEPS (87.5/100), despite flexion limitation to 95° (range, 80—110°) versus 130° (range, 100—140°) in the group with closed fractures.

Ulnar nerve injury was diagnosed postoperatively in six patients, of whom four had persistent ulnar nerve dysfunction at re-evaluation (16—46 months), including one with paresis. This last patient was a 77-year-old woman who declined ulnar nerve neurolysis at the elbow despite electrophysiological findings that supported this recommendation. In 1 patient managed with the transticipital approach, radial nerve paralysis was diagnosed postoperatively and resolved fully within the next 4 months.

Radiographs disclosed para-osteopoarthropathy in four patients. The ectopic ossifications consistently developed at the anterior aspect of the humerus, forming a bone block that limited elbow flexion (Fig. 3). Mean range of motion was decreased in these patients (0—40—118°), with a median motion arc of 78° (range, 70—120°) and an MEPS of 85 (70—100), i.e., comparable to the value in the other patients.

Secondary displacement of a C2 fracture due to material failure in the absence of further trauma occurred in an 89-year-old woman with osteoporosis whose distal humerus fracture had been managed using two orthogonal LCP DHP plates. She reported no elbow pain and her MEPS was 90. Consequently, there was no indication for surgical revision.

**Figure 1** Type C3 fracture: preoperative and postoperative radiographs. Note the difference in plate height designed to avoid a stress riser. The transolecranon approach was used in this patient.
Distal humerus fractures ORIF in older patients

Figure 2  Atrophic non-union of a type C3 fracture after internal fixation via the Bryan-Morrey approach.

Removal of the fixation material was required in four patients, three because of discomfort related to pinning-tension band wiring of the olecranon osteotomy and one because the olecranon pins migrated through the skin resulting in an early infection with methicillin-susceptible S. aureus. Subsequently, no secondary displacement of the osteotomy was detected.

Discussion

Fractures of the distal humerus raise therapeutic challenges related to the complexity of the local anatomy. Internal fixation using two plates is the reference standard treatment. With conventional constructs, secondary displacement due to material failure occurs in 5 to 30% of cases [17]. Construct instability allows micro-motion associated with a 2 to 11% rate of metaphyseal non-union [9,10,18,19]. Consequently, arthroplasty has been advocated in carefully selected elderly patients with complex comminuted fractures [3–8] (Table 1). The specific anatomic characteristics of the distal humerus require fixation of both columns with transverse epiphyseal screws to rebuild the arch needed to restore sufficient regional stiffness and to reconstruct the articular surface [20]. In addition to these reduction challenges, bone fragility may compromise construct stability. Consequently, a sufficiently large number of epiphyseal screws must be implanted, particularly into the distal fragment of the lateral column, where bone fragility is greatest and implant purchase most severely compromised [2]. The recent development of implants providing angular stability has expanded internal fixation possibilities and decreased the rate of mechanical complications by improving stability in fragile bone. These new implants have been proven effective when used to treat bone-insufficiency fractures in elderly patients; at the lower limb, they allow rapid resumption of weight bearing provided the fracture is extra-articular [21–24]. More specifically, the LCP DHP® system (Synthes) meets requirements for internal fixation of complex distal humerus fractures: multiple points of purchase in the epiphysis, anatomically shaped plates, fixation of both columns, and improved stability in fragile bone. Thus, LCP
Table 1  Previous studies of total elbow arthroplasty (Coonrad-Morrey or Discovery semi-constrained total prosthesis or Kudo or Latitude hemi-arthroplasty).

<table>
<thead>
<tr>
<th>Implant</th>
<th>No. of patients</th>
<th>Age (years)</th>
<th>FU (mo.)</th>
<th>Flexion loss (°)</th>
<th>Flexion (°)</th>
<th>Extension loss (°)</th>
<th>Motion arc (°)</th>
<th>Pain</th>
<th>MEPS [15]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb and Morrey [4]</td>
<td>21</td>
<td>Coonrad-Morrey</td>
<td>72</td>
<td>40</td>
<td>130</td>
<td>25</td>
<td>105</td>
<td>4 (20%)</td>
<td>93</td>
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<td>75% &gt; 90</td>
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<td>25% &gt; 75</td>
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<tr>
<td>Garcia et al. [5]</td>
<td>19</td>
<td>Coonrad-Morrey</td>
<td>73 (61-95)</td>
<td>36</td>
<td>5</td>
<td>25</td>
<td>6 (32%)</td>
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<td>93</td>
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<td>(80—100)</td>
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<tr>
<td>Charissoux et al. [27]</td>
<td>44</td>
<td>Coonrad-Morrey</td>
<td>81 (65—93)</td>
<td>24</td>
<td>124</td>
<td>27</td>
<td>—</td>
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<tr>
<td>McKee et al. [28]</td>
<td>25</td>
<td>Coonrad-Morrey</td>
<td>78</td>
<td>24</td>
<td>133</td>
<td>26</td>
<td>107</td>
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<tr>
<td>Chalidis et al. [7]</td>
<td>11</td>
<td>Discovery</td>
<td>80 (75–85)</td>
<td>34</td>
<td>117</td>
<td>10</td>
<td>107</td>
<td></td>
<td>90 (80–95)</td>
</tr>
<tr>
<td>Burkhart et al. [8]</td>
<td>10</td>
<td>Latitude hemi-arthroplasty</td>
<td>75 (62–88)</td>
<td>12 (6–24)</td>
<td>125</td>
<td>18</td>
<td>20% (1 moderate + 1 mild)</td>
<td>91 (60-100)</td>
<td>good + very good, 1 poor</td>
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FU: follow-up.
<table>
<thead>
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<th>Table 2 Previous studies of internal fixation.</th>
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<tbody>
<tr>
<td>No. of patients</td>
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<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Doornberg et al. [30]</td>
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<td>Shin and Ring [31]</td>
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<td>Charissoux et al. [27]</td>
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<td>Korner et al. [29]</td>
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<td>Kaiser et al. [33]</td>
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<td>Kaiser et al. [33]</td>
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<td>Greiner et al. [34]</td>
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<td>Our series</td>
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TTP: one-third tubular plates; PRP: 3.5-mm pelvic reconstruction plates; LCDCP: low contact dynamic compression plate; LCP DHP: locking compression plate distal humerus plate; FU: follow-up.
DHP® plates provide high-quality reconstruction, as well as sufficient stability to enable early mobilisation.

The surgical approach has a major impact on internal fixation quality and functional recovery. We gave preference to the transolecranon approach, which provides satisfactory exposure of the joint surface. Nevertheless, our data suggest that the olecranon osteotomy may significantly decrease the extension range and motion arc ($P < 0.05$). In contrast, Chen et al. [25] found better MEPS values and a greater motion arc (111.8°) after olecranon osteotomy than after the triceps-sparing approach in patients older than 60 years of age ($P > 0.05$). In our study, preferential use of the transolecranon approach in patients with complex type C fractures is a potential source of statistical bias.

Functional outcomes after distal humerus fractures are dependent on motion range recovery. Shorter periods of elbow mobilisation are, in theory, associated with better range of motion. Korner et al. reported that the duration of immobilisation should not exceed 2 weeks [26]. Consequently, a key objective of surgical treatment is to allow early mobilisation by developing increasingly stable constructs. Although immobilisation was used for more than 2 weeks in our study, the results were satisfactory, being comparable to those obtained in studies of screw-plate fixation and better than those reported with conventional fixation methods in patients older than 65 years [27–31] (Table 2). A number of other factors may influence functional recovery. Traumatic breach of the skin is a classical factor of adverse prognostic significance [1,19] that was associated in our study with greater flexion limitation, although neither the overall motion arc nor the MEPS were affected. Higher complication rates and worse outcomes have been reported in supra-inter-condylar fractures in several studies [1,32], in keeping with our data. The number of plates may influence recovery. In contrast, the duration of immobilisation had no significant impact in our study.

Ulnar nerve injury is a well-known complication of surgery via the posterior approach, with incidences ranging from 7 to 25% [8,9,27–35]. Although routine ulnar nerve transposition has been advocated [35,36], Chen et al. [25] reported a 33% rate of ulnar nerve dysfunction with transposition compared to only 9% without transposition in a population having a mean age of 49 years.

In keeping with studies by Kaiser et al. [33] and Greiner et al. [34], we found that material failure was less common with LCP DHP® plates than with conventional implants ($<5\%$ versus 5–30%). This point may explain the lower non-union rate with LCP DHP® plates. We believe the underlying reason is greater holding power of the material.

Conservative surgery may not be feasible in patients with severe comminution, very distal fractures, chronic inflammatory disease, or pre-existing osteoarthritis. Arthroplasty can be performed in these situations. Case-series studies of arthroplasty showed encouraging results with 110 to 140° of flexion, 10 to 30° of extension, and MEPS values indicating good or very good results in 81 to 100% of cases [4–8,27,28].

Thus, the introduction of locked plates seems to have benefited the management of distal humerus fractures, providing better functional outcomes, decreasing the rate of mechanical complications (material failure and non-union), and decreasing arthroplasty requirements. The high overall rate of complications, most of which had no major impact on function, nevertheless indicates a need for careful attention to the vulnerability of elderly fracture patients. In particular, the appropriateness of ulnar nerve transposition in this specific patient population deserves discussion.

Our results support the use of LCP-DHP® plates with angular stability in patients with osteoporosis or very small distal
Distal humerus fractures are complex lesions, particularly in elderly individuals. The objective functional and radiological outcomes documented in our study were good or very good despite a high rate of early postoperative complications, most of which were short-lived nerve dysfunctions. These outcomes seem better than those reported with conventional implants and comparable to those obtained in earlier studies of similar implants or of arthroplasty performed to treat similar lesions. Thus, the clinical and radiological outcomes in our patients confirm our working hypothesis. A number of factors predicted the outcomes: compound fractures were followed by greater motion range limitation with no difference in MEPS values; unicortylar fractures were associated with better functional outcomes than other fracture types despite slightly lower motion range values; and olecranon osteotomy seemed associated with decreased motion range and function. In contrast, the duration of immobilisation did not significantly affect motion range recovery or MEPS values. The high complication rate indicates a need for careful attention to the vulnerability of elderly patients, although the impact of complications on the final functional outcomes was limited.

Disclosure of interest


References

distale de l’humérus chez le sujet âgé. Rev Chir Orthop 2008;94:3:662 [In French].


