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Acute distal periprosthetic humeral fractures around intramedullary locked nail: 2 years clinical, functional and radiological evaluation after or and if with LCP extrarticular distal humeral plate

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Abstract...

Introduction: Postoperative periprosthetic fractures of the humerus after a shoulder arthroplasty have a reported prevalence in the literature of 0.6-2%. Meanwhile fractures occurring distally or around a locked humeral intramedullary nail are rare and there is no general consensus regarding the best surgical technique to manage these. In our brief reports we described a small case series treated with a new surgical tecnique: open reduction and internal fixation with a hybrid open-MIS tecnique using LCP 4.5/5.0 extrarticular distal humerus plate synthesis.

Materials and methods: A total of 5 patients with 2 years follow-up and a confirmed periprosthetic humeral fractures, extended distally or around a recent locked humeral intramedullary nail, were included in our institutional database from January 2018 to December 2020. Patients underwent implant removal about 1 year after the second surgery with open reduction and internal fixation with LCP extrarticular distal humeral plate. For the current analysis, clinical and functional outcome was assessed through: VAS, ROM and OES questionnairesAnterior-posterior and Lateral Humerus X-rays were obtained after the previous surgery, before hospital discharge and at each follow-up visit. We also performed CT scans at 6 months to evaluate the healing of each fractures.

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Results: In our study group, the mean age was 52, all patients had received an initial treatment with an intramedullary locked nail for a recent diaphyseal or metadiaphyseal postraumatic humeral fractures. Every patient was treated with a double approach: the first step involved the removal of the distal locked screw in supine position with anterior approach; the next step consisted of a posterior approach for open reduction and internal fixation with an hybrid open-MISS tecnique using LCP 4.5/5.0 extrarticular distal humerus plate synthesis. There were no intraoperative complications; intraoperative blood loss was minimal. Clinical, functional and radiological evaluation showed a progressive improvement during each follow-up steps. Complete bone healing was observed in all 5 patients. All patients returned to practice sports with the same functionality level as before the surgery (about 1 year after the second surgery).

Conclusions: The advantages of minimally invasive reduction and fixation tecnique showed a valuable biological and functional option for the management of these challenging perimplant fractures. This small case series demonstrates that periprosthetic distal humeral fractures can be successfully treated with a hybrid fixation technique, using a locking plate with percutaneous cerclages around the region at the overlying humeral nail. This treatment allows early and free mobilization of the joint proximal and distal related to the fractures and is associated with faster recovery, lower pain scores and improved quality of life.

Keywords: Periprosthetic humeral fractures; Intramedullary nail; Extrarticular locking plate fixation; Cerclage wires; Early rehabilitation.

Introduction

Periprosthetic humerus fractures will likely become more common with the increasing use of total and reverse shoulder arthroplasties [1-3]. The incidence of such fractures is approximately 1-2% and account for 11% of complications after shoulder arthroplasty. However, fractures occurring distally or around a locked humeral intramedullary nail are rare and their treatment is very challenging. Distal fixation is generally difficult because of osteopenia-osteoporosis and because of the presence of an intramedullary nail, which hinders the achievementof an effective proximal and upstream fixation of the fracture (at the level of the same segment). In addition, the increased invasiveness of the second surgery on a previous implant is likely to alter the biological healing processes of the fracture.

The aim of this case report and brief communication is to provide clinical, functional, and X-ray follow-up data at a 2 year follow-up of our patients with distally exteneded periprosthetic humeral fractures who have previously been treated with a locked humeral intramedullary nail for a diaphyseal segment fractureusing a hybrid open-MISS plating fixation with screws and metal wires. We believe this data can be valuable to clinicians and orthopaedic surgeons alike in making informed decisions for the surgical treatment of periprosthetic humeral fractures.

Materials and methods

Following Institutional Review Board (IRB) approval, we contacted all patients who underwent open reduction and internal fixation for distal periprosthetic humerus fractureswith previous locking intramedullary nail synthesis at ourinstitution and completed the 2-year follow-up. Patients were retrieved from alongitudinal prospective database of a single orthopaedic trauma center, started atour institution in January 2018.

All patients gave their written informed consent for the enrolment into the database.

The diagnosis of periprosthetic humerus fractures was made on clinical (i.e., symptoms, trauma history, previously operated with intramedullary nail fixation) and radiological (i.e., X-rays and CT scans) grounds. Indications for surgical treatment through open reduction and internal fixation in periprosthetic humerus fracture extended distally to a locked humeral intramedullary nail were as follows: Displaced humeral fracture around or distally with respect to a previously introduced intramedullary nail for the fixation of the diaphyseal segment, actual or impending neurologic compromise after humeral fracture after intramedullary nail fixation, intramedullary nail instability due the new fracture which can compromise the healing of the co-existent fracture. Anterior-posterior and Lateral Humerus X-rays were obtained after the previous surgery, before hospital discharge and at each follow-up visit. We also routinely performed CT scans at 6 months after the second surgery to evaluatethe healing of each fractures.

Patients were also asked to fill in Visual Analog Scale (VAS), ROM (Range of Motion), Oxford Elbow Scores (OES) questionnaires at each follow-up visit.

We carefully checked for non-union onset. A diagnosis of non-union was made when at least 9 months had elapsed from the fracture and no signs of healing were visible for at least 3 months [4]. Patients underwent implant removal about 1 year after the second surgery with open reduction and internal fixation with LCP extrarticular distal humeral plate. For the current analysis (2 years follow-up), clinical and functional outcome was assessed through VAS, ROM and OES questionnaires. Data are expressed as a mean with ranges, unless stated otherwise; counts and percentages are used when appropriate. Data was analyzed using Microsoft Office Excel 2016 Professional (Microsoft, Redmond, WA, USA).

Table 1: Demographic data.

Population characteristics (n=5)	
Gender	3 F; 2 M
Mean age (years)	52 (66-46)
BMI	29,87 (24,3-35,5)
Affected side %	2 right-sided (36,4%); 3 left-sided (63,6%)
ASA score %	4 grade II (72,72%); 1 grade III (27,28%)
Etiology %	2 traffic incidents 3 falls from height
Type of Fracture	3 fractures of distal diaphyseal segment without nail mobilization 2 fractures of distal diaphyseal segment
Prior implants/osteosynthesis	3 Expert Humeral Nailing System Synthes; DePuySynthes; 2 Multiloc Humeral Nailing System Synthes
Type of implant	5 LCP 4.5/5.0 Extra-articular Distal Humerus PlateSynthesibrid open-MISS plating fixation with screws and metal circles (Orthopaedic Cable System, De Puy Synthes Trauma, NJ, United States)
Surgical approach	All patients treated with double approach: first step removing distal locked screws with anterior approach; next step posterior approach for OR adn IF with LCP 4.5/5.0 Extra-articular Distal Humerus Plate Synthesibrid open-MISS
Preoperative functionality level	All patients practice sports (martial arts, cycling, horse riding)
Follow-up (months)	23,2 (11-26)
Comorbidity	2 Diabetes, 2 hypothyroidism, 3 hypertension

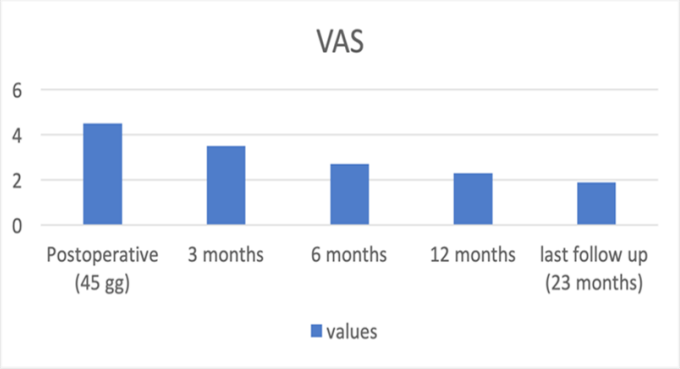

Figure 1: Post-treatment VAS (Visual Analogical Scale n = 2 years follow-up) are shown at 45 days, 3, 6, 12, months, last follow-up (average 2 years post-surgery) after surgical treatment with open reduction and internal fixation with LCP extrarticular distal humeral plate.

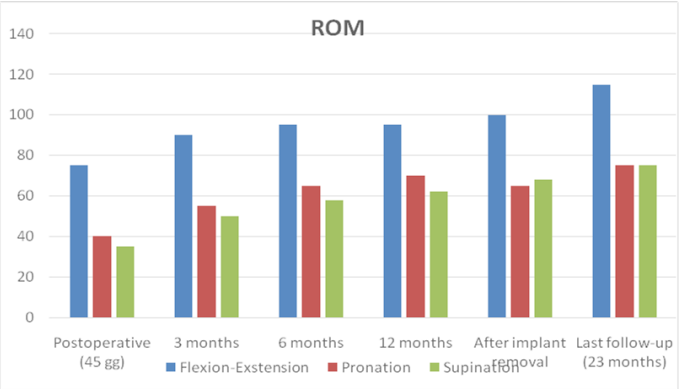

Figure 2: Post-treatment ROM (Range of Motion n = 2 years follow-up) are shown at 45 days, 3, 6, 12, months, last follow-up (average 2 years post-surgery) after surgical treatment with open reduction and internal fixation with LCP extrarticular distal humeral plate.

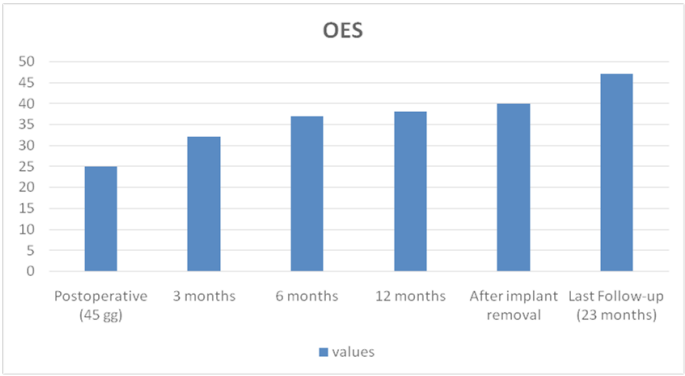

Figure 3: Post-treatment OES scores (Oxford elbow score n = 2 years follow-up) are shown at 45 days, 3, 6, 12, months, last follow-up (average 2 years post-surgery) after surgical treatment with with open reduction and internal fixation with LCP extrarticular distal humeral plate.

Results

A total of 5 patients with confirmed periprosthetic humeral fractures, extended distally or around a locked humeral intramedullary nail, were included in our institutional database from January 2018 to December 2020. All 5 patients were contacted for the current analysis and benefited from a 2 years follow-up. In our study group, the second injury was due to a traffic accident in 2 patients and to a fall from height in 3 patients.

The mean age was 52 with a range of 66-46 years, no patient died during the study and no patient was lost to follow-up. A review of the data showed a BMI mean value of 29,87 (min 24,3- max 35,5); the study included 3 patients with left side periprosthetic humerus fracture (63,6%) against 2 patients with right sided fractures (36,4).

All patients had received an initial treatment with an intramedullary locked nail for a recent diaphyseal or metadiaphyseal postraumatic humeral fractures. Between 3 weeks and 1 month after the first surgery these 5 five patients suffered a postraumatic periprosthetic humerus fracture extended distally or around the previous implant.

Previously, 3 patient had been treated with Expert intramedullary nail (De Puy Synthes Trauma, NJ, United States) for a diaphyseal humeral fracture while the other 2 patients had been treated with a Multilock intramedullary nail (De Puy Synthes Trauma, NJ, United States). Demographics and baseline data of the 3 patients included in the current study are summarized in Table 1. Every patient was treated with a double approach: the first step involved the removal of the distal locked screw in supine position with anterior approach; the next step consisted of a posterior approach for open reduction and internal fixation with an hybrid open-MISS tecnique using LCP 4.5/5.0 extrarticular distal humerus plate synthesis. There were no intraoperative complications;intraoperative blood loss was minimal (<100 mL).

The average hospitalization time in the orthopedic ward was 1,3 days for all patients.

The mean surgical time was 102.9 minutes (min: 94,6; max: 123,7). The mean blood intra-operative loss was 90 ml (min 60, max 188 mL). A mild improvement was recorded in the patient's clinical course, pain and quality of life. The average ROM at the final follow-up was 115 ± 10° in flexion-exstension and 75 ± 10° in pronation-supination. Complete healing was achieved in all patients; average healing time was 112.5 (84-140) days, confirmed by aCT scan at 6 months after the second surgery. Post-treatment VAS and OES score changes are shown in Figures 1 and 3, respectively. Progressive significant improvement in all scores was observed during the first 3 monthsafter the procedure. Improvements were maintained at the 2 years follow-up and increased after the implant removal (about 1 year after the second surgery). There was no evidence of screw loosening or failure of synthesis. Complete bone healing was observed in all 5 patients.

All patients returned to practice sports with the same functionality level as before the surgery (about 1 year after the second surgery).

Case presentation

A 68-year-old, left-hand dominant riding teacher presented to the emergency room with a left arm injury following an accidental fall from a horse. Her comorbidities included hypertension and autoimmune hypothyroidism. She had a BMI of 33, smoked 5 cigarettes per day and drank 6-8 alcoholic units with meals per day. She had a spiroid, angulated, mid-height fracture of the humerus with partial proximal stump elevation (fracture pattern AO/OTA 12 A1) (Figure 4). The patient underwent closed reduction surgery the following day and internal fixation with an anterograde intramedullary nail locked distally with 2 statically locking screws and proximally with a spiral blade type cephalic screw and a static locking screw (Expert Humeral Nailing Synthes; DePuy Synthes, Raynham, Massachusetts, United States) (Figure 5). One week after surgery, the patient abandoned the arm brace and began shoulder and elbow rehabilitation, and within 3 weeks she achieved a good functional recovery with a quick re establishment of autonomy for activities of daily living. At 30 days after surgery the patient returned following an accidental fall while horse back riding, with a complaint of arm pain, deformity of the anatomic profile of the elbow and functional impotence. X-Rays of the humeral shaft and elbow reported a peri-implant displaced fracture extending distally to the intramedullary nail and a third medial fragment at the distal locking screws (Figure 6). The patient underwent surgery for open reduction and osteosynthesis through a double approach in a single surgical time at 5 days after the trauma, after a period of damage control: 1) Firstly, in supine decubitus, the removal of the distal locking screws of the intramedullary nail was performed, 2) Secondly, with the patient in prone position, through the Bryan-Morrey type posterior approach to the distal humerus (transtricipital) neurolysis of the ulnar nerve was performed, which was protected during the procedure, reduction of the distal fragment with the distal portion of the intramedullary nail and of the third fragment with an interfragmentary screw. The internal fixation was stabilized with LCP 4.5/5.0. Extra-articular Distal Humerus Plate and fixed proximally with MISS technique (after reduction with collinear reduction forceps and fixation using metal circles (Orthopaedic Cable System, De Puy Synthes Trauma, NJ, United States) while distally to the intramedullary nail with 3 angular stability screws. At 15 days after the procedure, the patient left the humeral brace, performed three weeks of LIPUS Ultrasound Bone Growth Stimulator Low Intensity Pulsed Ultrasound (OSTEOTRON IV, ITO) treatment, and began progressive postoperative shoulder and elbow mobilization physiotherapy. At 30 days, radiographs showed signs of initial bone callus formation at the level of the distal fracture and in advanced stage at the level of the proximal fracture while at 3 months there was healing of the diaphyseal fracture with advancement in the healing status of both fractures with subsequent increase in rehabilitation work and muscle strengthening (Figure 7). At 6 months after fixation, symptomatic and radiographic union was confirmed with a CTscan (Figure 8) and the patient had a complete return to her daily and sports activities, with no associated pain.

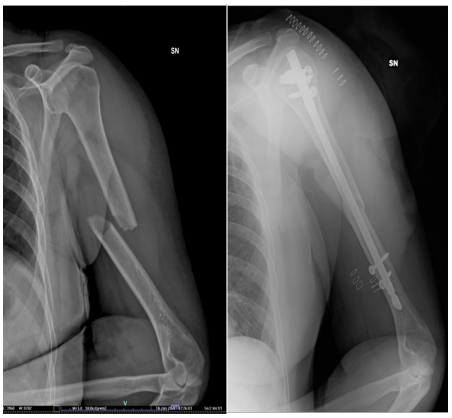

Figure 4,5: Preoperative diaphyseal postraumatic humeral fracture (4). Postoperative humeral fracture treated with an anterograd locked intramedullary nail (5).

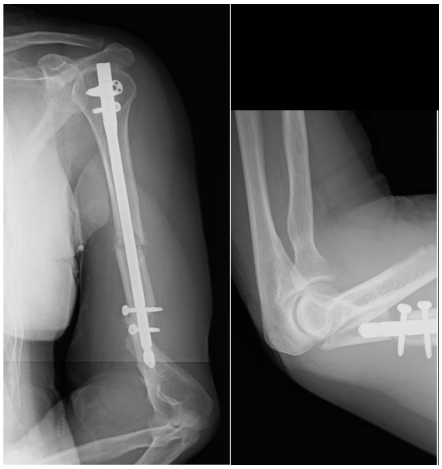

Figure 6: Antero-posterior view of the humerus showed a perimplant postraumatic fractures around and distal respect to the intramedullary nail after one months to the first surgery (6) Lateral view of the same fractures showed the gap between the distal locking screws respect to the distal segment of the humerus.

Figure 7: Six-month postoperative diaphyseal and distal periprosthetic fractures treated with hybrid open-MIS tecnique fixed with LCP extrarticular distal humeral plate and proximally with cerclages wires, showed healed fractures.

Discussion

Periprosthetic fractures of the distal humerus are uncommon and complex to manage. The following findings on the management of distal humeral fractures occurring near the humeral component of a shoulder or elbow arthroplasty have been published in the literature [5,6], of which only few are descriptions of such fractures occurring in the distal humerus below an intramedullary nail.

Risk factors associated with periprosthetic fractures of the distal humerus include advanced age, female sex, osteoporosis and rheumatoid arthritis, soft tissue contracture or deficiency [3,7]. We are aware of 2 cases of periprosthetic fractures of thedistal humerus following intramedullary nail fixation. Sarraf et al [8]. Describe a distal humerus fracture in a 72-year-old man following intramedullary fixation of a fracture of the middle third of the humeral diaphysis. Fracture union was successfully treated with bicondylar locking plate fixation with the addition of cerclage wires, performed through a posterior approach. Shin et al [9]. Describe the case of a young patient, without signs of osteoporosis, who underwent intramedullary nail osteosynthesis surgery for the treatment of a proximal humerus fracture. The periprosthetic fracture occurred 4 months after surgery and was a spiral course fracture of the distal third of the humerus below the nail. This was successfully managed with removal of the nail and then conservative management with splints and functional braces. The development of locking plate technology has changed the way complex periprosthetic fractures are treated, especially in fragile bones [10]. Greater fracture stability and biological osteosynthesis can be achieved with LCP conventional plates, and the rigidity or flexibility of the construct can be controlled by changing the plate length and screw/hole ratio [11]. Stripping or periosteal damage is minimized because these contoured locking plates are designed to be placed at the submuscular/epiperiosteal level, thus maximizing the healing potential of the fracture. Long splinting plate fixation is necessary for secure management of periprosthetic fractures around previous intramedullary nail by using the remaining cortex for screws anchorage in combination with cerclage wires. The goals of surgical treatment for periprosthetic humeral fractures include fracture union, maintenance of glenohumeral-elbow motion and restoration of overall function. These objectives can be achieved with immediate rehabilitation and stable osteosynthesis by periosteal vasculature-sparing mechanisms, which is realized through the use of a bridging plate (splinting plate fixation) used as an internal fixator (extrarticular plate) fixed distally using the remaining corticals and proximally using dynamic cerclages introduced minimally invasively [12]. Although the use of cerclage is currently considered a biologically disadvantageous method burdened by a limited number of complications such as transient neuroapraxia (approximately 25% of all periprosthetic humeral fractures) in the hands of experienced trauma surgeons it remains a safe and effective technique that allows direct visualization of the radial nerve and control of proper fracture reduction on the previous implant and synthesis stability with intraoperative testing [13,14]. The cerclage may function in two different ways: as a temporarily tool for reduction during surgery or can be used long term as an implant. The advantages consists in minimally invasive reduction and fixation tecnique, low cost and early holding. The improvement of passer tecnology allows a reduction of skin incision and tissue damaging, minimizes radiation exposure, vascular damage and performs a correct closure of the wire [15-18]. Removal of the extrarticular plate one year later has not shown an increased formation of periarticular calcifications.

The purpose of our study is precisely to demonstrate that this surgical procedure is equally safe and effective. In fact, hospitalization times and intra-operative blood losses were not higher than expected, and the surgical procedure did not last too long. This last data is relevant because it shows that open reduction and internal fixation with a hybrid open-MIS tecnique using LCP 4.5/5.0 extrarticular distal humerus plate synthesis, if performed by a senior surgeon with a quick and rigorous procedure, can be done rapidly without increasing the risk of non-union, implant instability, infections and blood loss. The excellent osteointegration of the implants and the absence of revisions, albeit limited by our short follow-up, demonstrate that the definitive procedure shows a lesser risk of malpositioning compared to the use of prosthetic components. On the other hand, we found only a few papers studying acute distal periprosthetic humeral fractures around intramedullary locked nailsin the literature. Our case series is certainly more recent because it goes from 2018 to 2020 and it is clear that surgical techniques and perioperative management of patients have changed during years. For example, the use of LAP (locking attachment plate) have limited the need for proximal fixation with cerclage metal wires and improved the adjacent plate fixation to the intramedullary nail [19], especially in minimally invasive periprosthetic proximal femur osteosynthesis.

Limitations

Our study has some limitations. We acknowledge the fact that the number of patients presented in this report is limited and a longer follow-up period of other patients will be needed to consolidate our results. We were however able to manufacture one of the largest and the oldest contemporary series present in literature.

Conclusion

Although periprosthetic distal humeral fractures are uncommon, they present a unique challenge for the management given the osteopenic/porous nature of the bone. This small case series demonstrates that periprosthetic distal humeral fractures can be successfully treated with a hybrid fixation technique, using a locking plate with an eccentric hole that facilitate pla-

cement of proximal skive screws. The cases we presented highlight the importance of vigilant follow-up and early, intensive rehabilitation. Basic prerequisites turn out to be stability along with adequate elasticity of the synthesis. More importantly, we demonstrate how these complexe fractures can be successfully managed with the use of a locking plate with a working length to avoid excessive stiffness and to reduce stress on the proximal fixation with a combination of unicortical locking screws and cerclages around the region at the overlying humeral nail. Our technique allows early mobilization of the shoulder and elbow, decreases pain, prevents implant instability of each device and guarantees clinical and radiological healing with reduced proximal and distal joint stiffness. No significant complications were noted in our first 5 patients who completed the 2-year follow-up. Overall satisfaction rate was high with a full return to activity daily living and sports.

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