INTERNAL FIXATION WITH LOCKING PLATE OF 3- AND 4-PART PROXIMAL HUMERAL FRACTURES IN ELDERLY PATIENTS: COMPLICATIONS AND FUNCTIONAL OUTCOME

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SUMMARY – Despite recent advances in operative techniques, internal fixation of (3- and 4-part) displaced proximal humeral fractures in elderly patients with osteoporotic bone remains controversial, sometimes followed by poor results. The aim of the present study was to evaluate outcomes of internal fixation with locking plate of multi-fragment proximal humeral fractures in elderly patients. The study cohort comprised 59 consecutive patients (mean age 70.1) with 3- and 4-part fractures who had undergone open reduction and internal fixation with locked plate at Sestre milosrdnice University Hospital Center in Zagreb, Croatia. All patients were invited for follow-up examinations and underwent standard x-ray examination preoperatively to assess fracture pattern in the operating theatre as well as at 6 weeks, 3 and 6 months, 1 year, and then annually after surgery to assess fracture healing or complications. Clinical outcomes were measured by constant score. Patients were followed-up for 14 to 36 months. The overall complication rate was 27.1%. The mean constant score at 1-year follow-up was 70.2 points for 3-part fractures *vs.* 64.2 for 4-part fractures ($p<0.0001$). In conclusion, despite a relatively high overall complication rate, internal fixation with locking plate provided moderate to good functional results in the treatment of osteoporotic complex proximal humeral fractures.

Key words: *Locking plate; Proximal humeral fracture; Elderly; Functional outcome*

Introduction

Proximal humeral fractures are one of the most common fractures seen in adults and account for 5% of all fractures[1,2]. The vast majority of these fractures are stable or only minimally displaced (80%-85%) and suitable for conservative treatment with good functional results[3-5].

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Surgical treatment of proximal humeral fractures is technically challenging and various procedures have been proposed to achieve stable fixation and satisfactory functional outcome. However, the treatment of displaced proximal humeral fractures is not derived from evidence-based decisions but rather from expert opinions and personal preference[6,7].

In the last decade, the introduction of new techniques employing a locking compression plate that provides high primary stability allowing for early rehabilitation, thus helping those techniques is gaining acceptance worldwide. These angular-stable plates allow for stable internal fixation because of

multidirectional locking screws anchored in humeral head[8-10].

All of this works well in simple 2-part fractures with good bone quality and theoretically with osteoporotic 3-part and 4-part fractures, with many advocating primary arthroplasty[11-13].

For the previously mentioned reasons, internal fixation of 3-part and 4-part fractures in elderly patients is still controversial.

Materials and Methods

In the period between January 2007 and July 2009, a total of 88 consecutive patients underwent open reduction and internal fixation of proximal humeral fracture with proximal humeral internal locking system at Sestre milosrdnice University Hospital Center, Zagreb, Croatia.

Ten patients had 2-part displaced proximal humeral fractures, and 78 had 3-part and 4-part fractures. Ten patients with 3-part and 4-part fractures were younger than 60 and as such were considered not suitable for inclusion in the study. All patients with multi-fragment fractures older than 60 were included in the present study and invited for follow-up examinations. The median follow-up was 19 (range, 7-31) months.

Another six patients who did not present for follow-up examinations as well as two patients with multiple injuries and one patient died from stroke in the early postoperative period were excluded from the study. Finally, the cohort study comprised 59 patients, 32 with 3-part and 27 with 4-part fractures.

All patients underwent standard x-ray examination preoperatively to assess fracture pattern, in the operating theatre for reduction evaluation, as well as at 6 weeks, 3 and 6 months, 12 months and then annually to assess fracture healing and function. The following parameters were noted: age, gender, fracture pattern, complications, and functional outcome using constant score.

Both groups of patients (3-part and 4-part fractures) were compared for complication rate and functional outcome.

Proportional data were tested for significance by using the Yates-corrected χ^2-test and all continuous data were compared by a two-tailed unpaired Student's t-test. A beta-coefficient of less than 0.05 was considered statistically significant.

Proximal humeral fractures met the indication for internal fixation according to Neer (angulations by more than 45° and more than 1 cm of displacement between major fragments).

The procedures were carried out by 3 experienced trauma surgeons familiar with PHILOS® plate, under general anesthesia. The patients were positioned in the beach chair position with completely mobile arm allowing for fracture reduction under fluoroscopic assistance. The deltoidopectoral approach was used with minimal soft-tissue striping in order to preserve blood supply of the humeral head. The anatomical reduction was performed and major fragments were provisionally fixed with K-wires. The plate was positioned about 5 mm distally from the tip of the greater tuberosity avoiding subacromial impingement. The displaced tuberosities were identified, reduced and fixed to separate holes in the plate by no. 5 nonabsorbable sutures. The reduction and implant position were confirmed under image intensifier control. The wound was irrigated and closed with suction drain.

An immobilizer was applied in the operating room. The fracture site was protected in immobilizer during next 3 weeks, with passive motion exercise under survey of the operating surgeon. For the next 3 weeks, a sling was used and active-assisted and active range of motion was started consecutively. In case of questionable fracture stability, we used abduction pillow and only limited range of motion for 6 weeks.

Results

There were 50 female and 9 male patients, mean age 70.5 (range, 60-81) years. The vast majority of fractures united without complications. The overall complication rate was 27.1%. We compared complication rate between 3-part and 4-part groups and found no significant differences. We found one case of wound infection that was minor in nature, and it was successfully managed by dressings and intravenous antibiotics. Both cases of humeral head osteonecrosis were complete. Complications are shown in Table 1. We also noted loss of fixation and screw cut-out in a few cases. The mean constant score in the follow-up period (3, 6 and 12 months after surgery) was signifi-

cantly better in the 3-part than in the 4-part group. Table 2 summarizes comparison of functional outcome assessed by constant score.

Table 1. Complications

Complication	3-part, n (%)	4-part, n (%)	P value
Loss of fixation	2 (6.3)	4 (14.8)	NS
Screw cut-out	3 (9.4)	(14.8)	NS
Avascular necrosis	0 (0)	(7.4)	NS
Infection	1 (3.1)	0 (0)	NS

NS = nonsignificant

Table 2. Constant scores

Follow-up period	3-part	4-part	P value
3-month CS (pts)	60.9±3.1	58.9±1.9	0.0054
6-month CS (pts)	68.7±1.7	62.6±4.7	0.0001
12-month CS (pts)	70.2±1.6	64.2±4.7	0.0001

CS = constant score; pts = points

Discussion

Surgical treatment of proximal humeral fractures is a quite frequently performed procedure in clinical practice and, therefore, is of great interest to patients, trauma surgeons, health insurance companies, and medical equipment industry. Proximal humeral fractures in elderly patients can be frustrating to treat. A part of frustration derives from the fact that internal fixation of proximal humeral fracture is generally considered to be "surgery of failure" due to poor bone quality and associated complex pattern. Osteoporosis in elderly patients with low energy trauma often leads to complex comminution, and poor bone quality renders fixation loose over time and impairs fracture healing[14-17].

Numerous surgical techniques have been employed in order to achieve sufficient stability for early mobilization and to spare blood supply, for instance, percutaneous K-wire fixation, minimal fixation techniques, tension band, plate fixation, nails, and hemiarthroplasty[18-22]. Internal fixation with buttress T-plate has been associated with increased avascular necrosis of the humeral head due to extensive periosteum striping. Sturzenegger *et al.* found 34% of avascular necrosis after T-plate osteosynthesis[23].

For this reason, some authors advocated minimal fixation techniques using screws, tension band or sutures[13,24-26]. However, previously mentioned techniques do not offer anatomical reduction and sufficiently stable fixation, thus requiring postoperative prolonged immobilization which interferes with functional result. Unacceptable complication rate (30%) has been reported, mostly implant associated problems such as loss of fixation and screw protrusion[27]. Kocialkowski *et al.* report on poor outcome in 69% of patients treated with percutaneous K-wire fixation[24].

A new generation of short proximal humeral nails with more stable proximal interlocking has been proved as a good technique indicated for A-type fractures, as well as for B and C fractures with additional use of sutures and cerclage wires for tuberosity fixation. The potential advantage of nails would be preservation of blood supply and soft tissue attachments, but there is potential interfering of the implant with rotator cuff[29].

A fixed-angle locking plates have recently been increasingly recognized as implants with biomechanical advantages superior to non locking plates[30-32]. This observation is supported by the results of Bartsch *et al.*, who found 2 cases of loss of fixation and displacement in 41 patients treated with stable-angle plates[33]. Mückter *et al.* report on good results in 27 of 32 elderly patients who underwent early rehabilitation[34].

In our study, we recorded a rather high overall complication rate of 27.1%. However, this incidence is comparable to those reported elsewhere and confirms complication rates of internal fixation of 3-part and 4-part fractures found in literature. Brunner *et al.* report on the incidence of complications while evaluating 158 proximal humeral fractures treated with locking plate and found the overall complication rate of 35%. The most often complication was primary screw protrusion (14%), followed by secondary screw cut-out (8%) and avascular necrosis (8%)[35]. Südcamp *et al.* have recently published results of a prospective, multicenter study with similar results[36]. In the present study, we compared complication rate between 3-part

and 4-part groups of patients and found no statistically significant differences.

There is currently a general consensus among surgeons that final functional result is related to the correct operative technique, particularly anatomic or near anatomic reduction, rather than to any other factors including bone quality and fracture pattern. Poor reduction of the major fragments including tuberosities always results in significant postoperative pain, restricted range of motion, and unsatisfactory shoulder function[7,37-39].

Functional outcome obtained by constant score at 3, 6, and 12 months after surgery was comparable with literature data. Our results showed a statistically significant difference in functional outcome between the two groups of patients ($p<0.0001$). At 1-year follow-up, the mean constant score for 3-part and 4-part fractures was 70.2 and 64.2 points, respectively. In their systematic review of treatment of proximal humeral fractures with locking plates, Thanasas *et al.* have recently reported even better results (mean constant score of 74.3 points)[40]. Another group of authors report on functional results after internal fixation with angular-stable locking plate in 187 elderly patients. The mean constant score was 70.6±17.6[36].

There are some authors strongly advocating primary hemiarthroplasty for elderly patients with 4-part fractures, poor soft tissue quality, and osteoporosis[13,41-42]. Recently, Solberg *et al.* analyzed records of 122 consecutive patients aged 55 or older with 3-part and 4-part fractures that were treated with locked plate or hemiarthroplasty. Despite a high complication rate, they found better functional outcome with the use of locking plate than hemiarthroplasty. The constant score for 3-part fractures in the locking plate and hemiarthroplasty groups was 71.6 and 60.4 points ($p<0.001$), respectively, while the respective score for 4-part group was 64.7 and 60.1 points ($p<0.19$)[43].

In conclusion, it should also be emphasized that surgeon must be aware of certain factors influencing construct strength and final outcome. We cannot control bone quality and fracture geometry, but we can control quality of reduction and implant placement. On the basis of our results and similar studies, we believe that correct operative technique of internal fixation with angle-stable locking plate can provide satisfactory results in 3-part and 4-part proximal humeral fractures in elderly patients.

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Sažetak

OSTEOSINTEZA KUTNO-STABILNOM PLOČICOM TRODJELNIH I ČETVERODJELNIH PRIJELOMA PROKSIMALNOG HUMERUSA U STARIJIH BOLESNIKA: KOMPLIKACIJE I FUNKCIONALNI REZULTAT

A. Matejčić, D. Vidović, M. Ivica, D. Đurđević, M. Tomljenović, M. Bekavac-Bešlin, A. Mijić, M. Punda, B. Bakota i *Z. Misir*

Unatoč novijim dostignućima operacijske tehnike unutarnja fiksacija (trodjelnih i četverodjelnih) dislociranih prijeloma proksimalnog humerusa kod starijih bolesnika s osteoporotičnom kosti i dalje je kontroverzna, ponekad praćena lošim rezultatima. Cilj ove studije bio je procijeniti rezultat unutarnje fiksacije kutno-stabilnom pločicom multifragmentarnih prijeloma proksimalnog humerusa kod starijih bolesnika. Studija je obuhvatila 59 bolesnika (srednja dob 70,1) s trodjelnim i četverodjelnim prijelomom, kod kojih je učinjena otvorena repozicija i untarnja fiksacija kutno-stabilnom pločicom u KBC „Sestre milosrdnice", Zagreb, Hrvatska. Svi bolesnici praćeni su poslijeoperacijski kroz redovne kontrolne preglede. Standardna radiološka obrada provedena je prijeoperacijski kako bi se ocijenio tip prijeloma, zatim 6 tjedana, 3 i 6 mjeseci te 1 godinu nakon kirurškog zahvata, a potom jedanput na godinu kako bi se ocijenilo zaraštanje prijeloma i komplikacije. Za mjerenje kliničkog rezultata korišten je funkcionalni zbir. Bolesnici su praćeni od 14 do 36 mjeseci. Ukupna učestalost komplikacija bila je 27,1%. Srednji funkcionalni zbir nakon prve godine praćenja bio je 70,2 za trodjelne prijelome i 64,2 za četverodjelne prijelome ($p<0,0001$). Zaključno, unatoč relativno visokom postotku komplikacija unutarnja fiksacija kutno-stabilnom pločicom pružila je srednji do dobar funkcionalni rezultat u liječenju složenih osteoporotičnih prijeloma proksimalnog humerusa.

Ključne riječi: *Kutno-stabilna pločica; Prijelom proksimalnog humerusa; Starije osobe; Funkcionalni rezultat*