



Humeral head necrosis after proximal humeral nailing: what are the reasons for bad outcomes?

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KEY WORDS

proximal humeral fracture
humeral head necrosis
interlocking nailing
screw protrusion
clinical outcome

ABSTRACT

Introduction: Humeral head necrosis (HHN) remains a major problem in fracture care. Neither its occurrence, its extent, nor its impact on clinical outcomes is predictable on the long term. This study was designed to evaluate clinical and radiological outcomes in patients depending on the influence of HHN.

Patients and methods: 32 patients with a 3–6 year follow up participated in this study. Their humeral fractures had been stabilized with a standard Targon PH nail (Aesculap, Tuttlingen, Germany) for an acute humeral head fracture. Constant score (CS), DASH score, UCLA shoulder rating scale, and Neer score were assessed. Range of motion (ROM) as well as pain during exercise was documented (VAS). HHN was detected radiologically and graded in stages 0–5.

Results: All fractures had healed. HHN was found in 10 cases (31.3%). 4 patients (12.5%) showed interlocking screw perforation as part of the head collapse caused by HHN.

Median CS was 73 (range: 24–85). There was no association detectable between number of fracture fragments and CS ($p \geq 0.631$). The median DASH score was 16.4 (range: 0–74.1), UCLA score 30 (range: 9–35), Neer score 80 (range: 29–100).

Three (37.5%) of the patients with a stage IV or V osteonecrosis reported about pain (twice VAS grade 4, once VAS grade 5). All patients suffering from pain were affected by high grade HHN and screw perforation. CS was non-significantly affected by HHN (75.5 vs. 63.5; $p = 0.12$), however massively diminished if additional implant protrusion was present (63.5 vs. 25; $p = 0.02$). Findings for normalised CS, relative CS, DASH score, UCLA shoulder rating scale, Neer score, and ROM were analogous.

Discussion: Whereas HHN itself seems to contribute only mildly to functional outcome, we identified screw protrusion as major predictor for bad clinical results. The high rate of HHN found in our study (31.3%) may be attributed to the inclusion of mild HHN and our long follow-up period, as it is known that late-onset HHN may occur more than 3 years after trauma.

Conclusions: HHN may lead to screw perforation, resulting in poorest outcomes. We recommend regular clinical and radiographic follow-up for at least five years in order to detect impending screw perforation and plan screw removal in time.

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Introduction

Fractures of the proximal humerus account for approximately 5% of all fractures and are the third most common fractures entity in people above 65 years of age, second only to fractures of the hip and the distal radius [1,2]. Despite the high incidence of these fractures,

there is currently no valid scientific evidence for the best treatment method [3,4]. There are several intra- und extramedullary fixation implants as well as arthroplasty. The goal of the treatment is to reduce pain and regain maximum functional outcome in a relatively short period of time.

All of these methods have reported complications such as pain, stiffness, implant failure, loss of reduction, nonunion, malunion, impingement, and osteonecrosis of the humeral head [5–9].

The follow-up of most studies is usually of 1 year or even less. However late osteonecrosis with humeral head collapse has been recently recognised to be more common than previously thought [10,11].

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The aim of this study was to evaluate the functional and radiographic outcome following an operation with Targon® PH nail 3–6 years after surgery.

Patients and methods

Patients

Patients presented in our institution with proximal humeral fractures which were stabilised with the Targon® PH nail (Aesculap, Tuttlingen, Germany) and had at least a 3 year follow up were eligible to participate. Indications for the Targon PH nail included any type of humeral head and proximal shaft fractures except for head split fractures, cases of severe rotator cuff arthropathy and unreconstructable comminuted fractures. Patients with primary or metastatic tumors, revision surgery, and operations performed with the long version of Targon PH nail (in our hands used predominantly for proximal shaft fractures and segmental fractures) were excluded. In total 32 patients participated in this study with a follow up range between 3 and 6 years. The mean age was 69.4 years with SD of 8.7 years; female proportion: 78.1%. At the time of surgery, all patients were still active, taking care of their household by themselves. In 65.6% the dominant arm was affected.

Radiographic evaluation

The fractures were classified according to the Neer classification system by the preoperative radiographs, if available by CT and in cases of doubt based on intraoperative findings. There were 8 patients (25.0%) with 2-part fractures, 17 patients (53.1%) with 3-part fractures, 4 patients (12.5%) with 4-part fractures. 3 patients (9.4%) had a fracture dislocation. The follow-up x-rays were evaluated for union, implant-related complications, signs of avascular necrosis according to Cruess [12] and the occurrence of resorption of the greater tuberosity. In addition, the cortical thickness of the humeral shaft was measured on the postoperative and the follow-up x-ray, to detect an osteoporosis based on the criteria of Tingart et al. [13].

Clinical results

Functional outcome was assessed using the Constant-Murley score (CS), the CS normalised for age and gender (CS^{age}) [14,15] and in relation to the contralateral side (CS^{cs}). Further the UCLA shoulder rating scale, the Neer score and the DASH score as a mere subjective score.

The force measurement was carried out with a spring scale by 90° abducted, pronated arm and stretched elbow. Pain during exercise was measured by VAS, rating 0–10.

Furthermore, time until convalescence (months until end of therapy), satisfaction (dissatisfied, satisfied, very satisfied), all secondary diagnoses and medication were gathered.

Operation and postoperative rehabilitation

All patients had been operated in beach chair position. A standard delta-split approach was used. Fracture reduction was obtained by semi-closed methods, with an elevator or with K-wires as joystick for least possible soft-tissue dissection. In 9 cases the greater tuberosity had been additionally secured with rope-over-bitt (ROB) type tension banding or an auxiliary screw. During and after completion of the osteosynthesis, fracture reduction and accurate screw placement was confirmed fluoroscopically in anteroposterior and lateral views. Postoperative active-assisted physiotherapy without limitation of range of motion began the first day after surgery. Loadbearing and resistive strengthening exercises were not allowed until at least 6 weeks after surgery until radiographs confirmed fracture healing.

Statistics

Statistical analysis was performed using SPSS 20. Data were analyzed with ordinary analysis of variance using Mann-Whitney-U test and Kruskal-Wallis test. To compare categorical variables the χ^2 test was used in cases with all expected values greater than five, otherwise the two-sided Fisher's exact test was used. *P*-values <0.05 were considered significant.

Results

Radiologic results

All fractures were radiologically healed.

Humeral head necrosis (HHN) was found in 10 cases (31.3%). 2 (6.3%) were classified as stage II, 4 (12.5%) as stage IV and another 4 (12.5%) as stage V. A total of 4 patients (12.5%) had suffered screw perforation as part of the head collapse caused by HHN. One patient reported that the nail had been removed in another hospital due to screw perforation. All patients with a higher grade osteonecrosis (HHN stages IV and V) were women. We found a significant lower cortical thickness on the postoperative x-ray in HHN cases of grades IV and V ($p=0.04$). The median was 3.2 mm (range 2.4–4.2 mm) in cases without a higher grade HHN and 2.8 mm (range 2.4–3.2 mm) in cases with a higher grade HHN.

In 16 patients (50.0%) we noticed a partial or complete resorption of the greater tuberosity. There was no association to be detected between tuberosity fixation (by screw or ROB) and later bone resorption in this area ($p=0.305$).

Clinical outcome

We found a median CS of 73 (range: 24–85), CS^{age} of 88.5 (range: 30–100) and CS^{cs} of 91% (range: 31–111%). The median CS^{age} was 89 (range: 73–100) in patients with 2-part fractures, 84 (range: 30–96) in those with 3-part fractures and 82.5 (range: 31–98) in those with 4-part fractures. The median CS^{cs} was 89% (range: 74–100) for 2-part fractures, 92% (range: 31–111%) for 3-part fractures and 82.5% (range: 31–98%) for 4-part fractures. There was no association between number of fragments and outcome ($p \geq 0.631$).

The median DASH score was 16.4 (range: 0–74.1), UCLA score 30 (range: 9–35), Neer score 80 (range: 29–100).

The median range of active anterior elevation was 145° (range: 10–170°), of active abduction 122.5° (range: 20–180°) and of active external rotation 30° (range: 5–60°).

Compared to the opposite arm, we found a median relative force (force^{rel}) of 84% (range: 0–159%).

There was no significant association between the medians of the clinical outcome scores (ROM, force, patient satisfaction) and fracture severity as measured by the number of fragments ($p \geq 0.29$).

Three (37.5%) of the patients with a stage IV or V osteonecrosis reported about pain (twice VAS grade 4, once VAS grade 5). All patients suffering from pain were affected by high grade HHN and screw perforation.

In respect of the greater tuberosity the two groups (resorption/no resorption) did not show significant differences regarding maximum force, ROM, and functional scores ($p \geq 0.19$).

Observed outcomes depending on HHN and screw perforation are shown in Table 1.

The median time until convalescence was 6 months (range: 1–18).

Discussion

Treatment methods for Neer-IV-fractures

Sofer et al. published the results of 33 patients treated with a T2 intramedullary nail. The limited number of 4-part fractures in their

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