



IMPLANT SELECTION ALGORITHM FOR SURGICAL TREATMENT OF PROXIMAL FEMORAL FRACTURES

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ABSTRACT

The authors studied comparative functional results of treatment in 62 patients with proximal humerus fractures. Neer classification was used to select an implant for fracture fixation. Patients were divided into 3 groups according to fracture fixation: fixation with the plate invented by doctors in our clinic, AO plate and intramedullary locking nail.

The functional results of treatment were studied according to the Neer scale, taking into account the average score. The best results were achieved in Group I – the average score was 97, since this group included patients with two-fragment fractures of the proximal humerus. These are the simplest fractures, which cause minimal damage to soft tissues during making surgical approach, and bone fragments are not released, which has a positive effect on their subsequent union. The use of the Neer classification allows selection of the optimal implant for fixation of proximal humerus fractures.

Keywords: Proximal humerus fractures, fracture classification, implants, surgical treatment, treatment results.

Introduction

The proximal part is usually defined as the part of the humerus that includes the head of the humerus separated by the anatomical neck from the greater and lesser tubercles and the surgical neck located below them. Fractures of the humerus at the level of the proximal part are one of the most common skeletal injuries; according to various authors, they account for 4-7% of all limb fractures and up to 80% of humerus fractures [1, 2, 3, 5] The relevance of the problem of treating fractures of the proximal part of the humerus is associated with the high frequency of unsatisfactory outcomes with both conservative (from 3.5 to 37%) and surgical treatment (from 1.6 to 57.1%). From 13 to 16% of fractures in this segment are multi-fragmentary with bone tissue





impression, which significantly complicates the task of internal fixation. [4, 5, 8]. In clinical practice, the classification proposed by S. Neer is more often used, allowing for a more accurate determination of indications for surgical treatment, since it is based on differentiation by the number of anatomical fragments of the fracture and the degree of their displacement [15,16].

The most complex three- and four-fragment fractures (according to the Neer classification) account for 13-16% of all fractures of the proximal humerus [16].

At least 30 different methods of their surgical treatment have been described in domestic and foreign literature. [6,10,11,12,]. The most commonly used are: osteosynthesis with plates and screws, intramedullary osteosynthesis (with blocking and using rigid structures such as the "TEN pin"), osteosynthesis with pins, osteosynthesis with external fixation devices, transosseous suture of bone fragments, primary unipolar endoprosthesis of the shoulder joint in cases of severe destruction of the proximal humerus [7,9,11,13]. Thus, the treatment of fractures of the proximal humerus is one of the most important medical and socio-economic problems of our time.

Purpose of the study

Optimization of approaches to surgical treatment of proximal humerus fractures and tactics of implant selection for various types of proximal humerus fractures.

Materials and Methods

We conducted a comparative study of the treatment results of 62 patients with proximal humerus fractures patients with proximal humerus fractures treated with different surgical methods. undergoing inpatient treatment in the adult traumatology department of the Republican Specialized Scientific and Practical Medical Center for Traumatology and Orthopedics of the Republic of Uzbekistan for the period from 2019 to 2024, including archival data.

There were 39 men (63.8%) among the patients, 23 women (36.2%).

General data on the distribution of patients by age with proximal humerus fractures are provided. The bulk of patients in all three groups range from 45 to 70 years old (62%), since at this time patients lead an active lifestyle, and people over 50 years of age are at risk of fractures due to osteoporosis, especially women. At the age of 18 to 45 years (19%) patients. The smallest number of fractures of the proximal humerus in the age from 70 to 85 years (13%).

We compared the results of treatment of patients with fractures of the proximal humerus using three implants: an external device developed by us, intramedullary





osteosynthesis with locking rods and a plate LCP (locking compression plate). and LPHP (locking proximal humerus plate).

Patients were divided into 3 groups, depending on the type of fracture based on the Neer classification and by the method of osteosynthesis with different implants depending on the number of fragments.

First group – patients with simple two-part (n=23) extra-articular fractures of the proximal iliac joint, which includes 23 patients with the simplest fractures, who used the extra-articular device developed by us (**FAP № 00608.22.02.2010**).



Fig. 1. Extra-bone device for osteosynthesis of fractures of the proximal end of the humerus

The extra-articular device for osteosynthesis of fractures of the proximal end of the humerus contains an extra-articular plate with holes and teeth for insertion into the head of the humerus, with oval-shaped grooves made in the plate, one hole under the teeth made in the proximal part, and the distal end of the device is made U-shaped. The oval-shaped grooves made facilitate the device and maximally preserve the periosteum, which improves bone regeneration.

The second group of patients with 2-3 fragmentary extra-articular fractures of the proximal humerus were fixed (n = 15) with intramedullary locking pins.

The third group consists of 24 patients with the most complex four-fragment extra-articular fractures of the proximal humerus at the level of the surgical neck (n = 24) fixation was performed with an LCP, PHILOS plate; This type of fracture required fixation of all fragments. All patients were operated on the basis of a clinical examination, a comprehensive examination, including anamnesis, examination and instrumental research methods (X-ray, computed tomography: MSCT). MSCT of the shoulder joint helps to verify additional damage to these fragments, which can significantly affect the tactics of the operation. Impression fractures of the articular surface are well visualized with multispiral CT. All patients underwent diagnostics of vascular-neurological disorders of the injured limb Dopplerography of vessels.



Upon admission to the hospital, all patients underwent immobilization of the injured upper limb using a sling bandage and rarely a plaster cast. Radiography of the shoulder joint area was performed both upon admission of the patient to the hospital and during treatment - to assess the dynamics of the treatment. We performed radiography of the shoulder joint in 2 projections on the day after the operation, and at 1.5-2.0 months, 5-6 months and 1 year after the operation. In preparation for the operation, all patients were determined for blood type and Rh factor, biochemical and general blood tests, general urine analysis, coagulogram, hepatitis markers HBsAg and HCV, HIV, ultrasound of the veins of the lower extremities, ECG, plain chest radiography. Before the operation, all patients were consulted by an anesthesiologist to decide on the choice of anesthesia method. The tactics of surgical treatment in preoperative planning depends on the degree of displacement of fragments and their number. This directly affects the choice of implant and surgical technique (minimally invasive intervention or open reduction and fixation). The Neer classification (Fig. 2) allowed the selection of an implant for surgical treatment of fractures of the proximal humerus depending on the number of fragments.

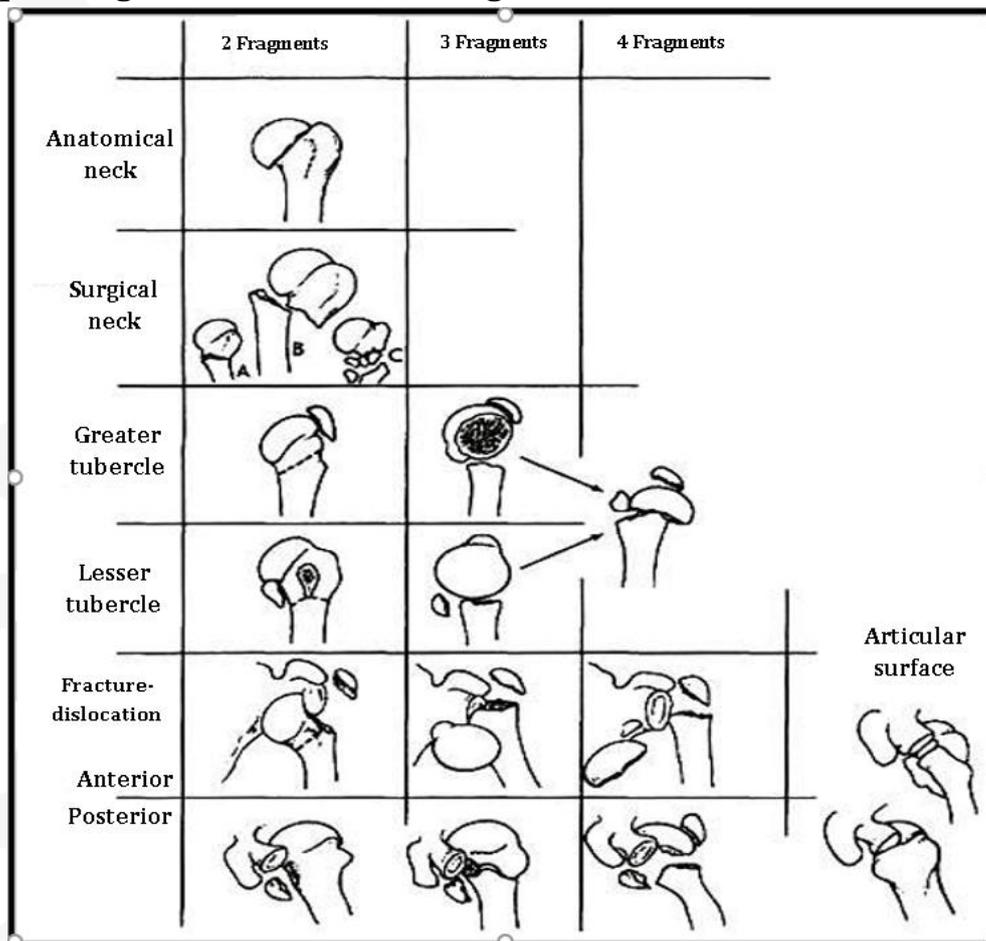


Fig. 2. Neer classification of proximal humerus fractures



We have developed an algorithm for treating patients with proximal pelvic fractures, which allows choosing the optimal method of surgical treatment depending on the nature of the fracture. (DGU No. 52604 of 04. 06.2025) based on the Neera classification. All patients were operated on according to the algorithm we developed.

Fig. 3. Fixation algorithm for different implants 2-, 3- and 3.4-fragment fractures

2-fragment	3-fragment	4-part fractures
Fixations with our plate	intramedullary osteosynthesis with a locking pin	Locking compression plate (LCP) with angular stability.

23 patients had a 2-fragment fracture of the proximal humerus, 15 had a 3-fragment fracture, and 24 had a 4-fragment fracture (according to the Neer classification)

Based on the algorithm for fractures of the proximal humerus, the implants were selected in the following order:

Group I - 23 patients, fixation of 2 and 3 fragmentary fractures of the proximal humerus with our plate.

Group II - 15 patients, intramedullary osteosynthesis of 2 fragmentary fractures of the humerus with a pin. performing osteosynthesis without exposing fragments under the control of an electron-optical converter (EOC) for a fracture at the level of the surgical neck. for the low invasiveness of the 30 method, it is minimally invasive, provides sufficient stability for fracture fusion. The use of a pin gives good anatomical and functional results Group III - 24 patients underwent fixation of 2, 3 and 4 fragmentary fractures of the humerus with an AO plate, a plate with angular stability LCP (locking compression plate). There are special versions of such a plate, modeled for the proximal humerus - LPHP (locking proximal humerus plate). Reducing the contact of the plate with the bone and limiting the pressure on it of the plate and screws made it possible to produce locking screws with the possibility of monocortical fixation with angular and axial stability. The new principle of polyaxial divergence of screws contributed to increased stability in osteoporosis and the possibility of using minimally invasive surgical techniques LPHP (plate with angular stability for the proximal humerus) and LCP (locking compression plate) plates during osteosynthesis on stability is not affected by the quality of the bone, due to the fact that the compression and tension forces, excluding the load on the bone, are transferred through the screws; The contact of the plate with the periosteal layer is point-like. As



a result of the fact that there is no pressure of the implant on the bone, thereby reducing trauma to the periosteum, which plays an important role in osteogenesis. The PHILOS plate has holes for suturing the rotator cuff. In addition to the locked holes, there are also combined holes, which make it possible to use both locking and standard cortical screws for fixation to create interfragmentary compression. The surgical approach for osteosynthesis of the proximal humerus fracture with deltoid-pectoral plates. The approach began 1-1.5 cm below the clavicle, in the area of the coracoid process, and 9-13 cm lower along the sulcus deltoideopectoralis. After dissecting the skin and subcutaneous fat, ven. Cefalica was retracted laterally. It penetrated deep between the fibers of the deltoid and pectoralis major muscles. The first is retracted outward, the second - inward. Along the incision, the aponeurosis is dissected. Fracture fragments are identified. The long head of the biceps serves as a landmark for determining the lesser and greater tubercles and the rotator cuff muscles attached to them.

Before performing osteosynthesis with a pin for the proximal section a 2-3 cm long skin incision was started from the acromial process of the scapula parallel to the fibers of the deltoid muscle; the muscle fibers were divided longitudinally. The insertion point is in the fossa medial to the greater tubercle. Before inserting the conductor, reposition was performed, the fragments were aligned in the correct position, then the conductor was inserted under EOP control, then the entry hole was widened and the pin was inserted, proximal and distal blocking was performed, a locking screw (plug) was inserted, the range of motion was checked and control images were taken using an EOP.

Let us present a clinical observation.

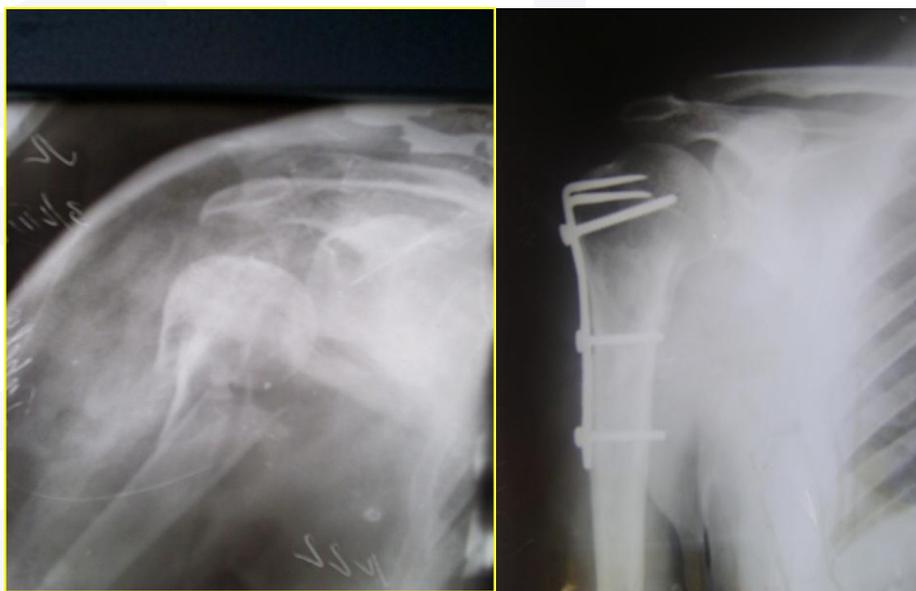




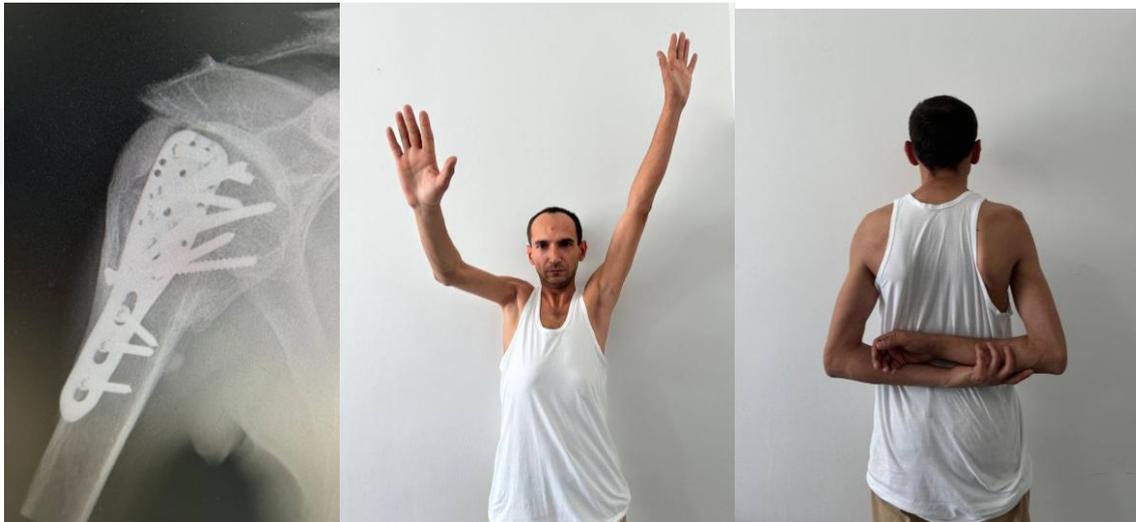
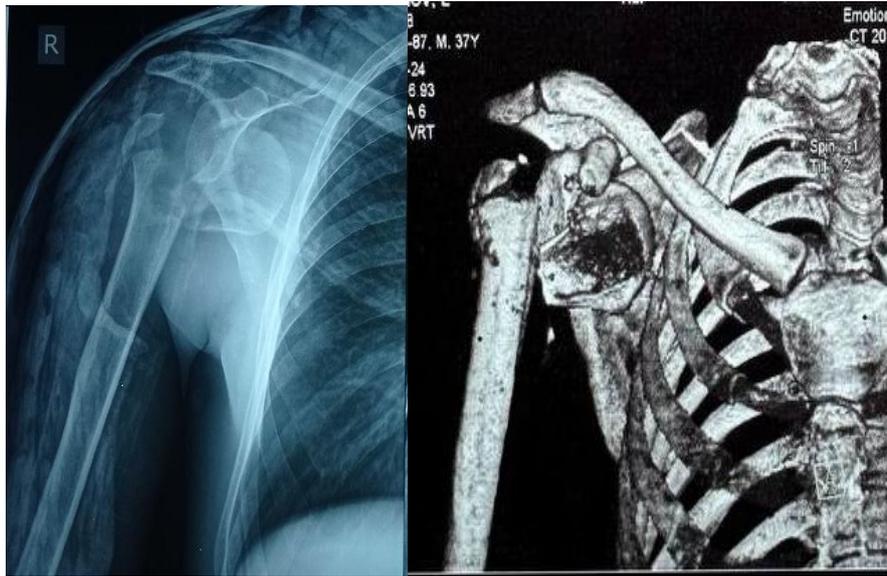
Fig. 4. Radiographs of patient P., 51 years old, osteosynthesis of a two-fragment fracture of the proximal humerus with a plate. Clinical picture: a – before b – 6 months after surgery, direct projection; c – 6 months after surgery.



Fig. 5.a, b, c. X-rays of patient B, 63 years old, before and after surgery. X-ray of intramedullary osteosynthesis of a two-fragment fracture of the proximal humerus.



Fig. 5. Function of the shoulder joint of patient E., 63 years old, 6 months after osteosynthesis of a three-fragment fracture of the proximal humerus with a intramedullary osteosynthesis : A – flexion; B – extension.



6. Radiographs of patient E., 1 year old, osteosynthesis of a four-part fracture of the proximal humerus with an LCP plate: a — before surgery; b, c — 6 months after surgery.

A — abduction; B — internal rotation

Results and Discussion

Six months after the operation, a clinical examination was performed using the Neer scale for two-, three-, and four-fragment fractures. According to the Neer scale, excellent treatment results are a score of 90 to 100, satisfactory from 80 to 89, unsatisfactory from 70 to 79, and poor less than 70 points. This scale is a 100-point system for assessing the condition of patients according to the following criteria: pain syndrome from 0 to 35 points, upper limb function - from 0 to 30 points, range of motion in the shoulder joint - from 0 to 25 points, and the presence of anatomical changes in the proximal humerus - from 0 to 10 points.



Functional results of treatment of postoperative patients

The table shows the functional results of treatment of postoperative patients according to the Neer scale, taking into account the average score in the groups; fixation of the fracture of the proximal humerus was performed with an NCB, PHILOS plate and a pin.

Table 1. Functional results of treatment of postoperative patients according to the nNeer scale, taking into account the average score in the group

Table 2.

Patient Group	Presence of anatomical changes in the proximal humerus (0–10 points)	Pain (0–35 points)	Upper limb function (0–30 points)	Range of motion in shoulder joint (0–25 points)	Total Score
Group I Osteosynthesis with our device	10 points	34 points	29 points	24 points	97 points
Group II Osteosynthesis with locking intramedullary nail	8 points	33 points	27 points	22 points	90 points
Group III Osteosynthesis with AO plate	8 points	30 points	28 points	24 points	88 points

The table shows that the best results were achieved in Group III - the average score was 97, since this group included patients with two-part fractures of the proximal humerus. These are the simplest fractures that do not require open reduction, cause minimal damage to soft tissues during access, and bone fragments are not isolated, which has a good effect on their further fusion. In Group 2, 90 points were mainly obtained due to the complexity of four-part fractures of the proximal humerus, since these fractures require open reduction and internal fixation, more extensive visualization of the fracture during surgery, which leads to more massive damage to soft tissues. With such fractures, the greatest damage to the rotator cuff occurs, all this negatively affects the further development of the shoulder joint and pain syndrome. But according to the mathematical model, PHILOS provides stable fixation of the fracture, as it has a polyaxial divergence of screws in the amount of 9, which allows fixing the lesser tubercle as well. The functional result in group 3 of 88 points was obtained mainly when fixing three-fragment fractures. Three-fragment fractures mainly required open reposition and internal fixation, which subsequently had a negative effect on the function of the shoulder joint, there was a limitation of movement in the shoulder joint, pain syndrome. Migration of screws was also





observed, which did not allow further development of the shoulder joint and led to a change in the tactics of postoperative treatment.

Complications

Results of complications in postoperative patients in all three groups.

In the first group, no complications were observed.

In the second group, one patient had a complication of impingement syndrome, which is associated with incomplete immersion of the pin into the medullary canal. During the operation, under EOP control, the pin position was correct. Postoperative radiographs showed incomplete immersion of the pin into the medullary canal. The patient was offered surgical treatment, which the patient refused, and shoulder joint development was started. It was possible to achieve 84 points on the Neer scale, with slight limitation of motion. In the third group, one patient (four-fragment fracture) developed adductor contracture of the shoulder joint due to the severity of the fracture and the severity of the postponing surgery, extensive visualization, and as a consequence, additional damage to soft tissues and no rehabilitation.

Conclusions

The choice of implant based on the Neer classification allowed us to draw the following conclusions:

1. In the first group, with osteosynthesis using our plate, excellent results were achieved in 82% of patients, and satisfactory results were achieved in 13% of patients.
2. In the second group, with osteosynthesis of two-fragment fractures of the proximal humerus using a pin, excellent results were achieved in 86% of patients and satisfactory results were achieved in 12% of patients.
3. In the third group, with osteosynthesis using the AO plate, excellent results were achieved in 80% of patients and satisfactory results were achieved in 16% of patients.

Thus, based on our research, we wanted to show:

1. For each type of fracture, an individual choice of fixation method is desirable depending on the number of fragments and the quality of the bone.
 - the most stable fixation for a two-fragment fracture is achieved with a pin for the proximal humerus.
 - Three-part humeral fractures can be fixed with a plate with at least 4 holes in the proximal part to fix all fragments and hold them in the correct position under loads such as arm abduction and support on the arm.
 - Four-part fractures should be fixed with a plate, which in the proximal part should have, as a rule, at least 7 locking screws. To fix and hold all fragments during early





development of the shoulder joint, and also have holes for suturing the rotator cuff, since it is quite often damaged in multi-fragmentary extra-articular fractures of the proximal humerus.

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