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Midterm Treatment Outcomes of Proximal Humerus Fractures by Intramedullary Fixation

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Abstract

Background. Treatment tactics of proximal humerus fractures remains a matter of dispute due to multiple cases of unsatisfactory outcomes and high rate of postoperative complications. ***The aim of the study*** — to evaluate midterm outcomes of intramedullary fixation for treatment the proximal humerus fractures in comparison with plate fixation. ***Materials and Methods.*** The authors evaluated treatment outcomes of 175 patients with proximal humerus fractures who underwent surgery in the period from 2012 to 2017. Depending on the fixation method the patients were divided into two groups: the main group consisted of 107 patients who underwent intramedullary fixation by a nail of third generation; a comparison group — consisting of 68 patients who underwent fixation by a locking plate with angular stability. ***Results.*** In one year after intramedullary nail fixation the authors observed the excellent and good outcomes on Constant scale in 83.2% of cases, satisfactory — 12.1%, unsatisfactory — 4.7%. Patients who underwent plate fixation demonstrated the following outcomes: excellent and good — 73.5%, satisfactory — 17.7%, unsatisfactory — in 8.8%. Constant score increase was equal in the main and control groups and varied depending on the fracture type. ***Conclusion.*** Intramedullary nailing is an option for treatment of all fracture types of proximal humerus as well as for the cases of combined humeral neck and diaphysis fractures. Functional recovery parameters were higher in the main group of patients after intramedullary nailing.

Keywords: proximal humerus fracture, intramedullary fixation, plating fixation.

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Introduction

Proximal humerus fractures belong to one of the most common types of injures in adults. They constitute 5–14% of the total number of skeletal fractures and 32–65% of humerus fractures [1–3]. Women are more likely to get this type of injury, their share accounts to 75% [4]. Frequency of such injuries increases with age: up to 70% of fractures of this localization are reported for patients over 60 years old with the peak incidence being at 80–89 years [4–6]. In 87–90% of instances, fractures in adults result from falling from their own height, and in younger people – from road accidents, catatrauma, athletic injuries, and work accidents [4, 6].

In 50–80% of instances, proximal humerus fractures are non-displaced or minimally displaced, which allows for conservative treatment with good outcomes [4, 5, 8].

In 15–20% of instances, proximal humerus fractures are multifragmentary and significantly displaced. The conservative treatment often leads to unsatisfactory functional outcomes resulting in the need for surgical treatment [2, 9].

As a rule, the Neer classification [10] is used for proximal humeral fractures. It divides the proximal humerus into four anatomic segments: humeral head, the greater tuberosity, the lesser tuberosity, humeral shaft. The classification includes non-displaced and minimally displaced fractures, as well as two-part, three-part, and four-part fractures. Last revised in January 2018, the Neer classification was integrated into AO/ASIF classification*.

There is still no consensus on indications for certain methods of surgical treatment. Choice of an optimal treatment policy and an implant model is remaining a subject of intense discussion [5, 8].

Today angular stable locking plates and locking intramedullary nails are primarily used for fixation of proximal humerus fractures. These types of implants fit the anatomic features of the proximal humerus and allow achieving primary angular stability due to locking screws oriented in three planes [11]. Each of the methods has advantages and disadvantages. Many authors consider open reduction and internal fixation (ORIF) using LCP plates [12] to be the golden standard of surgical treatment. Other authors prefer the intramedullary fixation method. There has been much research on using these implants, however, insufficient attention has been given to their comparison.

The purpose of the study is comparing midterm outcomes of surgical treatment of patients having proximal humerus fractures by intramedullary fixation and external fixation using an angular stable locking plate.

Materials and Methods

During the period from 2012 to 2017 the authors performed 317 internal fixation surgeries on patients with proximal humerus fractures, including 205 cases of intramedullary fixation by a proximal locking nail, and 112 cases of external fixation by a locking plate with angular stable screws. The research covered the outcomes of treatment of 175 patients.

The inclusion criteria were as follows: isolated trauma, no neurovascular injuries, age over 18 years. Humerus fracture-dislocations and ipsilateral injuries of the upper extremity were the exclusion criteria.

The research concentrated on monitoring midterm outcomes of 107 patients who underwent intramedullary fixation using short proximal humerus nails. Most of the patients were female – 79 (73.9%). The patients aged between 25 and 91 years, the mean age was 62 (±14.6) years. 61 (57.0%) patients were over 60 years old. According to the AO classification of proximal humerus fractures and fracture-dislocations (last revised in January

* https://www2.aofoundation.org/wps/portal/

2018), 42 (39.3%) fractures belonged to Type A (two-part fractures), 41 (38.3%) fractures – to Type B (three-part fractures), and 24 (22.4%) fractures – to Type C (four-part fractures).

The control group consisted of 68 patients who underwent external fixation of proximal humerus using an angular stable locking plate. Most patients of this group were also female – 47 (69.1%). The patients aged between 25 and 84 years, the mean age was 53 (±16.7) years. 40 (58.8%) patients were over 60 years. According to the AO classification there were 22 (32.4%) fractures of Type A, 29 (42.6%) fractures of Type B, and 17 (25,0%) fractures of Type C in the group.

The patients of both groups were monitored during period from 1 month to 5 years, the mean value was 1.9 years. The research covers the patients who were monitored for at least 12 months.

At admission to hospital patients were interviewed about circumstances of injury, their medical history was taken, and X-rays in at least two views were made. The following views are used for the shoulder joint: AP, transthoracic, axillary, and scapular. To determine quantity and a dislocation pattern of bone fragments, computed tomography (CT) with 3D reconstruction was carried out on the patients with fractures of Type B and Type C, which influenced the choice of a treatment method.

The patients of the main group with Type fractures and in some cases, Type B fractures, as well as combined fractures of the neck and the shaft of the humerus underwent closed reduction using minimally invasive access for nail insertion. In order to reduce the risk of secondary displacement and provide more stable fixation, the screw-in-screw locking method was used for treating the patients with multifragment fractures of the humeral head, as well as the patients with osteoporosis.

During the postoperative period, managing of all the patients was carried out in accordance with the AO standard rehabilitation protocol* which included immobilizing of the operated extremity by a triangular bandage for 2-3 weeks, early mobilization (in 24 hours after the surgery) under control of an exercise physiologist. At first, passive and pendulous movements were applied, which were gradually extended to active movements. After the fracture healing, a full exercise load was applied to the injured extremity. X-rays were taken in 1, 3, 6 and 12 months after the surgery.

On the average, the surgeries in both groups were performed in 3 days after the patients got injuries. The average duration of intramedullary fixation was 48.3 min (±13.3 min) for two-part fractures and 96.4 min (±32.5 min) for three- and four-part fractures.

The progress of the functional recovery of the injured upper extremity was evaluated in 1, 3, 6 and 12 months after the surgery. Treatment outcomes within the first 6 months were classified as short-term, from 6 months to 3 years – as midterm, and over 3 years – as long-term.

The main parameter was functional assessment of the shoulder joint according to the Constant Shoulder Score (CSS) [13]. It is a 100-point rating system consisting of several parameters that is designed for evaluation of a functional status after treating shoulder joint injuries. It consists of four subsections: pain (15 points), daily activities (20 points), muscle strength (25 points) and range of motion (40 points): elevation, abduction, external and internal rotation of the shoulder joint. The higher is the score, the better is the function [14]. In 12 months after the surgery, the CSS score of over 90 points indicated an excellent outcome, 90–80 points – a good outcome, 79–70 points – a satisfactory outcome, and <69 points – an unsatisfactory outcome.

Statistical analysis

Statistical analysis of the obtained data was carried out using Excel и OpenEpi Version 3.01. For quantitative characteristics the results were presented as absolute measures, arithmetic mean values (M) and standard deviations (σ); for qualitative characteristics – as relative measures expressed in percentage (%). For testing statistical hypotheses, the critical level of significance (α) was assumed to be 0.05. If normal distribution of values was confirmed, evaluation of statistical significance of differences between the groups was carried out using Student's t-test (*t*) for independent samples. In all instances, the differences were evaluated as statistically significant at $p<0.05$.

Results

The highest values in short-term and midterm periods, the highest improvement of function of the injured upper extremity and the shoulder joint according to the Constant score were observed in the patients with two-part fractures who underwent intramedullary fixation using a proximal humeral locking nail. The outcomes were evaluated as excellent and good. The outcomes of treatment in the control group were also evaluated as good and excellent, however, their Constant score was lower as compared to the score of the main group. The results did not reveal a statistically significant difference between the groups ($p = 0.067$).

The results of treating three-part and four-part fractures of the proximal humerus by intramedullary and external fixation are given in Table.

The results of comparing the midterm outcomes of treating various types of fractures in two groups of patients are given in Figure.

Thus, improvement of the CSS value is equivalent in both groups and varies depending on the fracture type. It should be noted, however, that the function recovery values are higher in the main group, and these differences are statistically significant ($p<0.05$; see Table for more detailed information about the values).

The following CSS values were obtained in the control group: 50 (73.5%) excellent and good outcomes, 12 (17.7%) satisfactory outcomes, and 6 (8.8%) unsatisfactory outcomes.

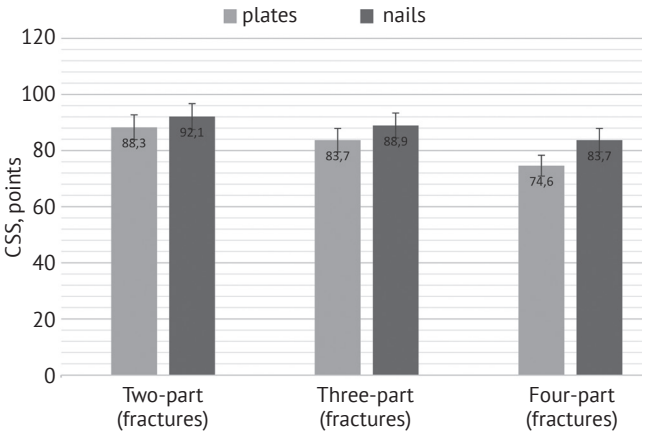

Fig. Results of treatment in 1 year (CSS), score

Table

Functional outcomes of treating three- and four-part fractures of the proximal humerus according to CCS

Groups	Fracture type	Score							
		1 month	*p*	3 months	*p*	6 months	*p*	12 months	*p*
Main group	B (*n* = 41) C (*n* = 24)	61.4±9.6 59.2±11.7	0.004	77.0±9.4 71.5±12.3	<0.001	84.8±9.4 79.8±13.2	0.001	88.9±10.3 83.7±15.4	0.032
Control group	B (*n* = 29) C (*n* = 17)	55.3±7.2 51.1±11.6	0.032	66.3±7.3 64.7±10.8	0.004	77.4±8.5 72.2±12.1	<0.001	83.7±9.5 74.6±16.8	0.027

The main group showed excellent and good CSS outcomes in 89 (83.2%) instances (mainly, these are the patients with the fractures of Type A and Type B), satisfactory outcomes – in 13 (12.1%) instances, unsatisfactory outcomes – in 5 (4.7%) instances. The most favorable outcomes were observed in the patients with isolated injuries that were treated using minimally invasive access, which reduced traumatizing the soft tissues, did not require open reduction of fragments, reduced the surgery duration and blood loss, and allowed starting more active rehabilitation during an early postoperative period. A higher CSS value observed during the first month after the surgery in the main group's patients as compared to the control group's patients demonstrated their faster and fuller function recovery of the injured upper extremity and the joint, which enabled the patients to return to their normal lifestyle earlier. It should be noted that operating on the patients later than 5 days after injury often resulted in difficulties, for example, it was difficult to perform accurate reduction during the surgery. Thus, in 6 cases (5.6%) it was required to extend an access to the fracture and perform open reduction. The patients who underwent surgeries within the first 3 days also demonstrated better functional outcomes.

The following complications of intramedullary fixation were discovered: osteonecrosis of the humeral head (in the patients with four-part fractures) – in 4 cases, fracture non-union – in 6 cases, osteolysis of the greater tuberosity – in 5 cases, migration of metal implants (mainly, these were proximal screws) observed in the elderly patients with the fractures of Type C – in 4 cases.

Complications of external fixation included osteonecrosis of the humeral head – in 5 cases, fracture non-union – in 3 cases, migration of metal implants (including screw penetration into the articular surface) – in 6 cases, subacromial impingement – in 4 cases. No infectious complications were observed in the patients after the surgery. The total number of compilations after intramedullary and external fixation were 8.4% and 15.7% accordingly.

Discussion

The literature describes many surgical methods of treating proximal humerus fractures. The choice of a method depends on the fracture type, state of bone tissue, a surgeon's experience and skills. Today the most frequently used methods are fixation by an angular stable plate, intramedullary nail fixation, minimally invasive fixation by screws or pins and shoulder replacement.

Several recent studies that compare the outcomes of intramedullary nail fixation and fixation by a locking plate in patients with two-part fractures have shown no statistically significant data about superiority of either method [15, 16]. For three-part and four-part fractures, the outcomes have been controversial, however, for these types of fractures most surgeons have recommended using external fixation by a locking plate [1, 17].

N.V. Zagorodniy et al. [17] describe excellent and good outcomes of treating two-part fractures of proximal humerus by external fixation using an angular stable plate, and good outcomes obtained by intramedullary fixation using second-generation nails. The average CSS scores after 1 year was 92.0±6.3 and 88.0±11.7 accordingly ($p = 0.96$). Application of these methods for treatment of three-part fractures has shown mostly satisfactory functional outcomes. Our research has shown similar functional outcomes of treating the patients with two-part fractures: 92.1±7.0 and 88.3±10.6 for treatment with nails and plates accordingly ($p = 0{,}067$).

ORIF LCP allows conducting more precise reduction but carries the risk of osteonecrosis of the humeral head as a result of impaired vascularization. The plate can cause subacromial impingement (usually, in case of its incorrect insertion), and there is the risk of external fixation failure in patients with

severe osteoporosis. According to T. Helfen et al. [18], application of angular stable locking plates in treating patients with osteoporosis for over a period of 10 years has shown mostly excellent and good results, however, there have been unsatisfactory outcomes in 16% of cases. The main reason was the need for revision due to secondary displacement (14%), which is also confirmed by other studies [19].

According to a meta-analysis conducted by R.C. Sproul et al. there is a high risk of secondary displacement for two-part fractures with gross dislocation or dislocation that affects the most part of the metaphysis (AO 11-A3), especially in patients with osteoporosis [20].

N.V. Zagorodniy et al. describe 5 cases of screw penetration into the articular surface of the humeral head as a result of applying plates, which is more often observed in patients with osteoporosis. The overall rate of complications was 31% in the group treated by external fixation [17].

V. Murylev et al. [21] describe a great number of complications observed in 12–35% of cases. In our research, unsatisfactory outcomes were observed in 8.8% of cases of external fixation using LCP plates, however, the number of observed complications was 15.7%, which is similar to the results obtained by T. Helfen. It should be noted that additional application of calcar screws that are inserted into the inferio-medial fragment of the humeral head during plate fixation is explained by a lower risk of secondary displacement as compared to fixation without using calcar screws [22].

The methods are constantly upgraded and supplemented by new capabilities depending on complexity of fractures, a patient's condition and requirements to health and functional outcomes. Locking fixation systems with angular stability have better internal stability; therefore they can better maintain fragments after reduction during the period of postoperative functional treatment [26, 27]. However, as to the proximal humerus, nails have significant advantages over plates [12]. One of the main advantages is maintaining blood circulation and minimizing surgically-induced soft-tissue traumatizing. Surgical access is usually carried out through small incisions without direct fracture intervention. An implant is inserted into the intramedullary canal along the biomechanical axis of the bone. Due to its centered position, the lever arm of the screws is lower than in a plate, in which the screws are in an eccentric lateral position. Also, nails are more biocompatible and easy-to-use for treating fractures of the humeral head that affect the diaphysis or segmental fractures of the humeral head and the diaphysis. Since a nail is inserted in the intramedullary direction and its proximal end is implanted in a subchondral direction, the risk of subacromial impingement is lower as compared to fixation by a plate (the latter needs to be removed because of that) [29]. In modern implants (third-generation implants), in order to enable proximal locking to be more stable, one can use the screw-in-screw method, which is not applicable in case of using nails of the previous generations [26]. This fixation method is especially relevant for elderly patients with severe osteoporosis.

In several recent studies, C. Cuny et al. have demonstrated good and excellent outcomes of treating two-part and three-part fractures [29, 30]. In the research by N.V. Zagorodniy et al. the complication rate for intramedullary fixation was 4% [17]. But it should be pointed out that this work describes patients with two-part fractures. In our research, the complication rate for intramedullary fixation was 8.4% in the patients with two-part, three-part and four-part fractures.

The conducted study has a number of restrictions that affect its quality and statistical significance. First of all, it is a retrospective study. All the surgeries were performed by different surgical teams with different qualifications. The observation period of 12 months was insufficient for a comprehen-

sive evaluation of the treatment outcomes. However, the authors consider the obtained results to be promising and encouraging further research. In the future the authors plan to evaluate long-term outcomes of surgical treatment by an intramedullary locking nail in comparison with external fixation by an angular stable locking plate in patients with proximal humerus fractures.

Conclusion

The research results demonstrated that fixation by a locking intramedullary nail is more efficient in the short-term and midterm post-surgical periods as compared to fixation by an angular stable locking plate. Due to an advanced screw locking system, nail fixation is suitable for treating proximal humerus fractures of all types. This fixation method is the treatment of choice for elderly patients as it ensures sufficient stability of fragments and outperforms other internal fixation methods in terms of treatment outcomes.

The study complies with the ethical standards of the Bioethical Committee of Pirogov City Clinical Hospital No. 1, Moscow Healthcare Department, that were developed in accordance with the World Medical Association's Declaration of Helsinki on ethical principles for medical research involving human subjects and the Rules of Clinical Practice in the Russian Federation approved by Order No. 266 dd. June 19, 2003 of the Ministry of Health of the Russian Federation. All the patients had given informed consent to participating in the research.

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