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Damage analysis of the tendon-capsular apparatus of the shoulder joint in multifragment fractures of the proximal humerus

Análisis del daño del aparato tendinoso-capsular de la articulación del hombro en fracturas multifragmentarias del húmero proximal

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SUMMARY

The research relevance is determined by the detection frequency and complexity of surgery for proximal shoulder fractures in different age categories. **Objective:** *The study aims to compare the proposed treatment method of the presented diagnosis with the traditional acceptable one.* **Methods:** *Patients with a diagnosis of proximal shoulder fracture were selected for the study and the corresponding results were obtained using clinical research methods. The total number of patients in different categories of fractures and dislocations shows the variety of complications doctors may encounter when treating humerus injuries. The breakdown of patients by diagnosis is as follows: two-fragment fracture – 88 patients; two-fragment fracture-dislocation – 31 patients; three-fragment fracture – 140 patients; three-fragment fracture with dislocation of the articular surface of the humeral head – 23 patients; four-fragment fracture – 47 patients; four-fragment fracture with dislocation of the articular surface of the humeral head – 17 patients.* **Results:** *The study concluded that the described methodology is minimally invasive and has more advantages than disadvantages. In addition, the postoperative and rehabilitation period after fixation with screws and plates is much shorter than with traditional methods of treatment. The practical significance lies in the use of the newest proposed method of surgery and fixation of bone structures together with tendons and other components using fixation screws and plates. This technique should be considered an alternative to other methods of treating this disease, and it has several advantages.*

Keywords: *Fixation, integrity disorders, osteosynthesis, osteoporosis, senility.*

RESUMEN

La relevancia de la investigación está determinada por la frecuencia de detección y la complejidad de la cirugía para fracturas proximales de hombro en diferentes categorías de edad. **Objetivo:** *El estudio tiene como objetivo realizar un análisis comparativo del método propuesto de tratamiento del diagnóstico presentado con los tradicionalmente aceptables.* **Método:** *Se seleccionaron pacientes con diagnóstico de fractura proximal de hombro para el estudio y se obtuvieron los resultados correspondientes utilizando*

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métodos de investigación clínica. El número total de pacientes en diferentes categorías de fracturas y luxaciones muestra la variedad de complicaciones que los médicos pueden encontrar al tratar lesiones del húmero. El desglose de pacientes por diagnóstico es el siguiente: fractura de dos fragmentos: 88 pacientes; fractura de dos fragmentos-luxación: 31 pacientes; fractura de tres fragmentos: 140 pacientes; fractura de tres fragmentos con luxación de la superficie articular de la cabeza humeral: 23 pacientes; fractura de cuatro fragmentos: 47 pacientes; fractura de cuatro fragmentos con luxación de la superficie articular de la cabeza humeral: 17 pacientes. **Resultados:** *El estudio concluyó que la metodología descrita es mínimamente invasiva y tiene más ventajas que desventajas. Además, el período posoperatorio y de rehabilitación después de la fijación con tornillos y placas es mucho más corto que con los métodos tradicionales de tratamiento. La importancia práctica radica en el uso del método de cirugía propuesto más nuevo y la fijación de estructuras óseas junto con tendones y otros componentes mediante tornillos de fijación y placas. Esta técnica debe considerarse como una alternativa a otros métodos de tratamiento de esta enfermedad con varias ventajas.*

Palabras clave: *Fijación, trastornos de la integridad, osteosíntesis, osteoporosis, senilidad.*

INTRODUCTION

Limb injuries remain not only a complex medical problem but also a social and psychological one that creates several inconveniences in a person's everyday life. Damage to the upper limb due to an injury can significantly impair the quality of life. Svyrydenko (1) determined that the upper limb is a complex multi-link biomechanical system, and even a minor injury to a single link can lead to dysfunction of the entire arm. The research relevance is determined by the frequent detection of upper limb injuries, especially of the humerus, shoulder and elbow joints, as well as in the controversial nature of the modern treatment of this injury. The problem is the complexity of the injury itself and the choice of the right tactics in treatment and subsequent rehabilitation.

Fractures of both the distal end of the humerus and the proximal shoulder can have severe consequences and require appropriate treatment. Due to the nature of the fractures, humeral fractures and supracondylar fractures are among the most common injuries in this area. According to statistics, they account for the lion's share of intra-articular fractures of the elbow joint, which is confirmed by the range from 47.5 % to 80 % (2). In turn, Lyutik et al. (3) report that humerus fractures are a significant medical problem, accounting for 2.2 % to 12 % of all bone fractures. Among them, fractures of the proximal humerus account for the most important proportion – 65 %. Fractures of the bone body (diaphysis) are the second most common, accounting for approximately 20 %. The lower part of the humerus, or its distal section, suffers fractures in 15 % of cases. In Ukraine, fractures of the humerus diaphysis are rare, accounting for 3 to 5 % of the total number of fractures (4). Moreover, there is a clear bimodal age distribution of cases of diaphyseal humerus fractures. The highest number of cases was recorded in men aged 21 to 30 years and in elderly women aged 60 to 80 years.

Bilinskyi et al. (5) and Kononenko and Pelypenko (6) argue that there has been a significant progression and change in treating humerus fractures over the past 20 years. The development of osteosynthesis technologies has led to the emergence of many high-tech instruments that allow for more accurate, efficient and safe fracture fixation procedures (7). However, despite these achievements, information support for medical staff on using new techniques and tools remains insufficient. Although important, numerous seminars and short-term courses may not cover osteosynthesis vulnerabilities with fixation. Following Korzh et al. (8), fractures of the proximal humerus account for approximately 5 %-6 % of musculoskeletal injuries. In particular, about 80 % of proximal shoulder fractures are of the AO/OTA A2/A3 type and are usually stable, and conservative treatment in such cases allows achieving good functional results. In addition, the authors note that such fractures deserve special attention and treatment in the presence of concomitant pathology, in particular, osteoporosis.

Given that such fractures are quite challenging to treat, there is a need to use the latest modern methods. Various implants are widely used for prosthetics in case of large defects of long bones. This can not only save the limb but also restore its

function. Alloplastic materials provide optimal conditions for the growth of new bone and the restoration of bone structures (9). In addition, these materials can be biologically compatible with the body, which reduces the risk of rejection and promotes a faster healing process. In turn, Golovakha and Chornyi (10) point out that carbon composite materials are a new class of structural materials for implantation. They are successfully used in osteosynthesis and endoprosthetics of bone structures due to necessary physical, mechanical and chemical properties. In some respects, such structures are superior to traditional metal and polymer implants. This makes them promising materials for use in traumatology, orthopedics, and other areas of medicine where high-strength and low-weight implants are required. Thus, the presented statistics demonstrate the significance and diversity of humerus fractures, which can result from various traumatic situations.

This project aims to enhance the outcomes for patients with proximal humerus fractures by creating a sophisticated treatment plan that uses cutting-edge osteosynthesis methods. The goals include evaluating how well these approaches work in comparison to conventional surgical treatments in terms of lowering complications, speeding up rehabilitation, and enhancing overall functional outcomes.

LITERATURE REVIEW

Treatment of fractures of the proximal humerus

There are several studies on the surgical treatment of proximal humerus fractures, but few compare the long-term results of contemporary osteosynthesis techniques with those of conventional approaches. This work aims to fill a gap in the literature by investigating the integration of sophisticated anchoring systems with periosteal osteosynthesis, which has not been extensively studied in the literature.

Fractures of the proximal humerus should be considered a severe medical problem, especially among the elderly. Following Korzh and Makarov (11), they are among the three most common fractures in this category of patients, being the third most common after femur and radius fractures. For most patients over 65 years of age with fractures of the proximal humerus, conservative treatment is used. Nonetheless, Bodnya and Dubovyk (12), Garkusha et al. (13), Zhetenbayev et al. (14) note in their works that surgical techniques of treatment are conceivable if there are signs. Among them: open reduction and internal fixation (this is a surgical method in which open access to the fracture is performed and then internal fixation is performed using special materials (e.g. metal plates and screws); closed reduction and percutaneous fixation (the method involves closed reduction of fracture fragments without open access to the bone and fixation by inserting screws or plates through the skin); blocked intramedullary osteosynthesis (consists of the introduction of intramedullary or medullary fixation using special nylon or metal sticks); hemiarthroplasty (a surgical intervention in which only one component of the shoulder joint is replaced, usually the humeral head); total anatomical shoulder replacement (a surgical intervention in which both components of the shoulder joint – both the humeral head and the scapula – are replaced); reverse total shoulder arthroplasty (an intervention used in cases of large joint defects or inability to perform arthroplasty, where the position of the components of the arthroplasty is changed, providing better stability and function of the joint). In turn, Lisunov and Bogdanova (15) and Pavlychko et al. (16) describe the method of total alloplasty. Total shoulder arthroplasty is one of the methods of treating multi-fragment fractures of the proximal humerus. Following Piven and Lyahovskiy (17), this method wholly or partially replaces the affected joint with a prosthesis, which allows for restoring joint function and reducing pain. Combined with rehabilitation techniques, such as thrombectomy with sequential myodesis, total shoulder arthroplasty can help achieve satisfactory functional results in all patients after surgery.

Treatment of rotator cuff of the shoulder

Rotator cuff tears in anterior dislocation of the shoulder often require appropriate treatment. Following Strafun et al. (18), most often, tears of the rotator cuff of the shoulder joint, combined with trauma, are observed in anterior dislocation of the shoulder. According to the authors, this

type of injury is observed in 56 % of rotator cuff tears. This is determined by anterior dislocation of the shoulder, which causes significant stress on the shoulder joint structures, including the rotator cuff, which leads to its damage.

Andriichuk et al. (19) describe various types of surgical treatment for the restoration of the rotator cuff of the shoulder joint: arthroscopically-guided rotator cuff suture (this method is used to treat damaged cuff tissue using a miniature camera (arthroscope) inserted through small incisions in the skin); open rotator cuff suture (the method is used when it is necessary to repair the damaged cuff by open access to the shoulder tissues); refixation of the tuberosity with rotator cuff suture (the procedure involves restoring the structures of the shoulder joint and fixing the tuberosity with rotator cuff sutures); transposition of the latissimus dorsi tendon (the method uses tissue from another part of the body to restore damaged rotator cuff structures); implantation of an InSpace balloon or biomatrix (these techniques are used to fill defects in the rotator cuff and create favourable conditions for its restoration); reverse arthroplasty (used when other methods of treatment do not lead to improvement in the patient's condition and includes replacing the damaged joint with an artificial endoprosthesis) .

MATERIALS AND METHODS

A group of 346 patients diagnosed with a proximal humerus fracture was selected and underwent clinical examinations from 2008 to the present. The total number of these patients was divided according to the specifics of the diagnosis: 88 patients with a two-fragment fracture, 31 patients with a two-fragment fracture-dislocation, 140 patients had a three-fragment fracture, 23 patients had a three-fragment fracture with dislocation of the articular surface of the humeral head, 47 patients had a four-fragment fracture, 17 patients had a four-fragment fracture with dislocation of the articular surface of the humeral head.

All patients had fractures with a rotational component of more than 45 and a diastasis between the fragments of more than one cm. This indicates the severity of the injury and may indicate the need for surgical intervention to restore the anatomical integrity of the bone tissue. Patients ranged in age from 26 to 83 years, with an average age of 67.5 years old. This parameter is addressed when planning treatment, as the course of the disease and treatment covers possible age-related peculiarities that affect the healing and rehabilitation process. The gender ratio in the group revealed 184 men and 162 women. This may indicate that there are likely differences in trauma mechanisms and treatment needs between men and women. All patients were operated on for the disease presented. Diagnosing shoulder rotator cuff damage was performed in the preoperative period using ultrasound and, in some cases, magnetic resonance imaging. This demonstrates the importance of accurate diagnosis and mandatory consideration of shoulder musculotendinous injuries when planning treatment. These data helped understand the characteristics and consider the peculiarities of treatment of patients with proximal humerus fractures and, accordingly, for further planning of therapeutic strategies and rehabilitation. This study used clinical methods: visual examination of patients, palpation of the affected area, and instrumental methods such as ultrasound diagnostics, computed tomography, and magnetic resonance imaging. Each group of patients was examined separately. The study groups were operated on using the presented method (using special screws and a plate to which the parts were fixed), and the results of the proposed treatment were compared with the control group with a similar diagnosis who were treated with conventional surgical techniques.

The most relevant literature sources were selected to analyze and form an idea of treating proximal shoulder fracture, which mentioned promising surgery methods for patients with this diagnosis. In addition, recent literature was used to draw parallels with the results of a similar study by colleagues and predecessors and highlight the presented research's advantages and disadvantages. For this purpose, modern data from the scientometric databases Scopus, Web of Science, and PubMed chronologically from 2020 to 2024 (the last five years) was selected. The search for information is based on keywords and terms: "traumatology", "orthopedics", "fracture","dislocation","fracture","operation",

"prosthesis", "screws", "plates", "fixation", "osteosynthesis", "rehabilitation", "diagnosis", "shoulder", "shoulder joint", "correlation", "fixation devices".

This study was conducted following all the accepted principles of the WMA Declaration of Helsinki (20) on "Ethical Principles for Medical Research Involving Human Subjects." The ethics committee of the university clinic approved it positively.

RESULTS

The analysis and generalization of the causes of disability in people with proximal humerus injuries show that this may be caused not only by the severity of the injury but also by other factors (21). According to medical expertise, a certain role in disability after upper shoulder girdle injuries is played by shortcomings in the organization and methodology of patient treatment, as well as underestimation of the role of functional therapeutic care.

To obtain reliable data on the issues raised, the study included 88 patients with two-fragment fractures – 58 out of 140 patients with three-fragment fractures – 138. The data above denotes a need for reinsertion to restore the integrity of the rotator cuff in these groups of patients. This applies to patients with three-fragment and four-fragment fractures, as well as those who have had a fracture dislocation. This is reflected in the fact that the design of the plate with screws used for periosteal osteosynthesis did not always ensure anatomical contact between tendons and bone, which can be an important factor in restoring shoulder function and preventing further complications. Reinsertion with additional anchoring was used to ensure proper rotator cuff repair and to achieve optimal anatomical contact between the tendons and bone. This approach can be important for achieving successful clinical outcomes and restoring shoulder function in patients with these types of fractures.

During the presented study, the anchoring technique or the technique of fixation with screws to a plate in a proximal humerus fracture showed the best results. This confirms the importance of choosing the proper fixation methods to achieve optimal treatment results and restore shoulder joint function. This technique ensures stable attachment of tendons and bone fragments, contributing to effective healing and restoration of joint mobility. The use of screws in combination with plates allows for high stability of the bone fragments, which reduces the risk of displacement and promotes proper healing. The anchoring system ensures a firm and stable attachment even in severe damage. Reduces the risk of re-displacement of bone fragments and damage to surrounding tissues. Patients treated with anchor fixation experienced a faster recovery of functional activity of the joint.

Damage can include tears or dislocations of these muscles or their tendons, leading to pain, limited movement, and loss of shoulder function. Treatment can range from conservative methods, such as physiotherapy and medication, to surgical interventions, including reinsertion or repair of damaged tissue. Diagnosing a rotator cuff injury is usually done through a physical examination, instrumental imaging techniques such as X-rays, ultrasound (US), or magnetic resonance imaging (MRI), and assessing the patient's symptoms and medical history. The optimal treatment method depends on the extent and nature of the injury and other factors such as the patient's age and activity (22). Since the proximal humerus consists of the humeral head, humeral tuberosity, and humeral condyle, a multifragment fracture can involve a bone tear in any of these areas and sometimes in all of them. The treatment of multifragmented fractures of the proximal shoulder can be complex and requires an individual approach depending on the size and nature of the fracture, the patient's age, general condition, and other factors (23). Treatment methods may include conservative osteosynthesis, surgical osteosynthesis using plates and screws, and, in complex cases, shoulder arthroplasty.

The use of rotator cuff tendonoplasty in cases of humeral head fragmentation can be justified to restore normal tone to rotator cuff muscles that may be damaged or weakened by trauma or surgery (24). The postoperative period is critical for assessing the recovery of upper limb function. The Constant-Murley and Disabilities of Arm, Shoulder and Hand (DASH) scores are assessment tools used to objectively evaluate the functional outcomes of postoperative upper

extremity rehabilitation (25,26). These scales allow for different aspects of function, such as pain, movement limitations, muscle strength, and overall functionality (Table 1). The scores on these scales help surgeons and physicians draw objective conclusions about the effectiveness of treatment and the need for further rehabilitation or correction of the treatment approach.

Table 1. Differences in the results obtained depending on the use of different scales

Criteria	Constant-Murley scale	DASH scores
Assessment of shoulder joint stability	+	-
Definition of pain syndrome	+	+
Assessment of the functional condition of the shoulder joint	+	-
Assessment of the range of motion in the shoulder joint	+	-
Strength assessment of muscles of the shoulder joint area	+	-
Rate possibilities for patient self-service	-	+
Need to take painkillers.	-	-
Assessment of the level of performance	-	+

Source: compiled by the author.

Due to the difficulty of performing traditional methods for the treatment of rotator cuff and proximal humerus fracture, we proposed a novel method of correcting a multifragment fracture using anchor fixators and plates with screws attached to it (27). Surgical treatment of multifragment proximal humerus fractures may include two stages to restore the anatomical relationship between the proximal humerus and the tendon-capsular apparatus of the shoulder joint. According to the data, out of 346 patients with fractures of the proximal humerus, 287 (83 %) required reinsertion, restoration of integrity, and, in some cases, further tendonoplasty and rotational shoulder cuff using additional anchoring. This indicates that a significant number of patients have complex injuries that require specialized surgical intervention. Correct surgical techniques and modern fixation methods, such as anchoring systems, are necessary to ensure stability and promote effective healing during surgery.

The first stage is to restore the anatomical position of the fractured bone fragments by employing surgical repositioning and fixation. This may involve the use of various types of fixation materials, such as a plate with screws or other osteosynthetic materials, to ensure stability and restore the anatomical position of the bone fragments. The first stage of elastic fixation of a fracture of the proximal humerus involves the use of anchor fixators that are inserted into the head of the humerus. This allows for anatomical reconstruction of the humeral head and restoration of the congruence of the articular surfaces. During this stage, transosteal fixation of the fragments is also performed, which helps to achieve dynamic stability of the proximal shoulder. This process involves fixation of the humeral head, humeral tuberosity, humeral condyle and diaphysis fragments to ensure stability and correct positioning of the bone fragments. The first stage also involves the reinsertion of the tendon-capsular apparatus of the shoulder joint and the suturing of defects using anchor fixators. This restores the integrity and functionality of muscles and tendons, which is necessary for the normal functioning of the shoulder joint after a fracture.

The second stage involves the restoration of the tendon-capsular apparatus of the shoulder joint. This may require reinsertion of the rotator cuff or other tendon structures that may have been damaged due to the fracture. Additional methods, such as physiotherapy rehabilitation, may also be used to restore joint functionality and prevent further complications. The second

stage of rigid fixation of a fracture of the proximal humerus includes periosteal tension osteosynthesis using a plate with locking screws. After the first stage is completed, when elastic fixation with anchor fixators has already been performed, the bone fragments are fixed with a special plate that is attached to the bone surface with screws. This process creates a rigid fixation of the fragments of the proximal humerus, which avoids further displacement or deformation and promotes fracture healing (28). The screws that lock into the plate ensure stable fixation and allow the necessary pressure to be applied to the bone fragments to enable them to grow together. The combination of elastic and rigid fixation allows for achieving optimal results in treating multifragment fractures of the proximal humerus, ensuring structural stability and accelerating the healing process. This approach allows not only the anatomical structure of the bone to be restored but also the stability and functionality of the shoulder joint, which is key to a patient's successful recovery after a traumatic injury. This suggests that, in addition to the traumatic event itself, it is necessary to address the rehabilitation process and the post-treatment period (29). Organizing effective rehabilitation and providing patients with the required physical therapy equipment and programs can significantly increase the chances of full recovery of function and improve the quality of life (30). This approach can also reduce disability and positively impact victims' social adaptation and well-being.

Anchors are used in surgical procedures to fix tendons and other tissues to bones. In the context of treating shoulder rotator cuff injuries, anchor fixators can be used to attach damaged tendons to the bones of the shoulder joint. This can include torn tendons, torn muscle parts, or other injuries. The procedure for installing anchor clamps usually involves the following steps: surgical access (the surgeon accesses the damaged area of the shoulder); bone preparation (a hole is drilled into the shoulder bone or a slight depression is made to accept the anchors); anchor fixation (the anchors are inserted into the prepared holes and fixed in the bone); tendon reattachment (damaged tendons of the rotator cuff of the shoulder are sutured to the anchors); postoperative period (the patient undergoes rehabilitation procedures to restore the function of the shoulder joint and rotator cuff). Using such anchorages can stabilize and restore the function of the rotator cuff after an injury (31).

The technical result of the combined osteosynthesis of the proximal humerus consists of several key aspects: reducing the risk of developing avascular necrosis of the humeral head (this is achieved through adequate fixation of fracture fragments, which ensures optimal blood supply to the humeral head and prevents its necrosis); early rehabilitation of patients (a combined approach to osteosynthesis allows for a shorter postoperative period and faster start of rehabilitation measures, which helps to restore the functionality of the upper limb); prevention of movement disorders in the shoulder joint (restoration of the anatomical relationships and tendon-capsular apparatus of the shoulder joint allows avoiding deformities and restrictions of mobility in the shoulder joint, ensuring optimal functionality of the upper limb). These technical advances contribute to improved quality of care and outcomes for patients with multifragmented proximal humerus fractures (32).

Screw fixation of bones is one of the methods of osteosynthesis used for proximal shoulder fractures. This method involves fixing bone fragments with special screws, which are considered to be a mechanical support for bone fragments. In the case of a proximal shoulder fracture, screw fixation can be used to stabilize the bone fragments as they grow. This method can be beneficial in cases where other fixation methods, such as plates or wires, cannot provide sufficient stability or are unsuitable due to the nature of the injury or patient's condition (33). Screw fixation can be performed either with conventional metal screws or with specialized screws, such as cannulated screws, which have a specific shape and design for better fragment retention. This osteosynthesis method can be performed either open or using minimally invasive or arthroscopic techniques, depending on the particular circumstances and the surgeon's choice.

The indicated need for reinsertion to restore the integrity of the rotator cuff in patients with three- and four-fragment fractures, as well as those with fracture dislocation, indicates the severity of damage to this structure in cases of

multifragment fractures of the proximal humerus. The rotator cuff plays a key role in stabilizing and moving the shoulder joint, so its damage can significantly affect the functionality of the upper extremity. In the case of a prolonged fracture or a fracture with dislocation, a significant tear or separation of the rotator cuff muscle tissue may occur, requiring surgical intervention to restore it (34). These findings emphasize the importance of paying attention to assessing the rotator cuff during the diagnosis and treatment of patients with multifragmented proximal humerus fractures. Early detection and restoration of the integrity of this structure can improve treatment outcomes and reduce the risk of postoperative complications. Thus, the use of anchor fixation together with reinsertion of the rotator cuff is an important step to ensure effective restoration of the structure and function of the shoulder joint after a multifragment fracture of the proximal humerus (35).

Anchoring provides stable attachment of tendon structures to bone tissue, which promotes proper growth and healing during the healing process. This is especially important in the case of a multifragment fracture when the tendon structures can be damaged or torn into several parts. This comprehensive approach not only restores the structure of the rotator cuff but also ensures its proper functioning, improving treatment results and facilitating faster patient rehabilitation. After comparing with similar techniques and traditional methods of treating this pathology, the study concluded that in all the presented groups of patients, this method of fixation with screws and plates proved to be more effective.

DISCUSSION

Disability resulting from diseases and injuries to the musculoskeletal system can lead to serious limitations in motor activity, which harms the development of other body systems. Widespread restrictions on motor activity create unfavorable conditions for the normal psyche and sensory system functioning and can lead to visceral disorders (36,37). Developing and implementing innovative rehabilitation approaches, including virtual reality technologies and robotic devices, can help improve treatment outcomes and adaptation to new living conditions for people with musculoskeletal disabilities. The study recorded that out of the above 346 patients with proximal humerus fractures, the need for reinsertion to restore integrity was detected in 287 cases, which is 83 % of the total number. In addition, in some cases, it was necessary to perform tendoplasty and use a rotational shoulder cuff with additional anchoring. These high rates are quite indicative of the urgent need to improve the diagnosis of proximal shoulder fractures both at the preoperative preparation stage and during surgery. There is a problem with the effectiveness of the design of the plate with screws used for periosteal osteosynthesis. This design does not always ensure complete anatomical contact between the tendons and bone, which can complicate the process of rehabilitation and restoration of shoulder joint functionality after an injury. Therefore, there is a need for further research and improvement of osteosynthesis methods to achieve better treatment results in patients with fractures of the proximal humerus.

The shoulder's rotator cuff is a group of four muscles and their tendons surrounding the upper extremity's upper part, connecting the upper arm bone to the shoulder joint (38). These muscles and tendons help rotate and stabilize the shoulder joint and provide support and mobility in the arm. In the presence of a fracture in this area or the proximal shoulder, there may be difficulties with the choice of further correction technique. A similar methodology to the one presented in their works is presented by Hättich et al. (39) and Sumrein et al. (40). The authors describe the treatment of a fracture of the proximal humerus using osteosynthesis. The use of special intramedullary "nails" is common in studies. The difference from the described technique is that the authors used refixation with an additional suture with glassine. This method of nail implantation for fixing a humerus fracture requires surgical access through an incision in the skin and fascia. A skin incision is made in the lateral angle of the acromion, and then the fascia and rotator cuff are dissected. After repositioning the fracture, the nail is inserted into the most cranial point of the humeral head. Sun et al. (41) emphasize that a targeting device under fluoroscopic control

ensures proper proximal and distal nail fixation. This allows the surgeon to accurately position the nail and ensure its correct placement for optimal fracture fixation. This approach can help reduce the risk of complications and improve patient outcomes.

Hohmann et al. (42) and Alzobi et al. (43) describe the effectiveness of open reduction and internal fixation in treating proximal shoulder fractures. According to the analysis, this method is superior to hemiarthroplasty. This may be due to better restoration of the anatomical structure and function of the shoulder and a lower incidence of complications. Although this method may be less effective than open reduction fixation, it may still be an option for some patients, especially when considering specific clinical situations and individual factors. According to the analysis, reverse shoulder arthroplasty is superior to hemiarthroplasty but comparable to internal fixation regarding clinical outcomes, range of motion, and complication rates (44). This may indicate that reverse arthroplasty may be an effective option for some patients. Thus, according to Schultz et al. (45) and Wendt et al. (46), there are various methods of treatment for proximal humerus fractures, and the choice of a particular method may depend on multiple factors, such as the patient's age, type and severity of fracture, joint condition, and general health. Non-surgical treatment is usually used for uncomplicated fractures with minimal displacement. This approach may include wearing support, therapy to reduce pain, and physiotherapy to restore mobility. Intraosseous fixation involves the use of screws, locking plates, or intramedullary nails to stabilize the fracture and ensure proper bone growth. Arthroplasty is more commonly used in patients with significant joint damage or those who cannot restore shoulder function using other methods (47). For example, a hemiarthroplasty (replacement of a part of the joint) or a complete shoulder replacement may be recommended.

What is distinctive about the work of Baker et al. (48) is that the specialist describes the tactics of managing elderly people with a fracture of the proximal shoulder. Thus, a non-surgical approach to treating proximal humerus fractures may include immobilization and physiotherapy. Depending on the characteristics of the fracture and the patient's condition, different immobilization methods can be used, such as a cuff and collar, a standard sling, a plaster arm or shoulder cast, or a particular aircraft splint. However, it is necessary to note that some immobilization techniques, such as wheeled arm and shoulder braces, are now considered outdated and are not recommended due to their lack of effectiveness and the potential for complications. Specialists now prefer more modern and effective methods of immobilization and physiotherapy to achieve optimal treatment results (49,50). Conservative treatment of fractures of the proximal humerus is used in cases where there is minimal displacement of fragments (up to 2-3 mm) or a high threat to the patient's life during surgery. In such situations, short-term immobilization is effective with positive clinical results. This means that in case of insignificant displacement of the fragments or in cases where surgical intervention may be excessively risky due to a high threat to the patient's life, a conservative approach to treatment is established. This approach may involve immobilizing the affected limb with a plaster cast or special orthosis for a certain period. As Kokkalis et al. (51) and Taskesen et al. (52) note, treating humerus fractures can be conservative or surgical, depending on the nature and severity of the injury. A conservative approach may include the use of plaster casts or special support to stabilize and ensure the restoration of bone structures.

The "middle mean" in treating most patients with a fracture of the proximal humerus, especially in the case of displacement of the tuberosities, is a fixation with various types of Locking Compression Plates (LCP). LCP is a type of plate used to stabilize fractures. It has special holes for screws that allow them to be soaked into the plate, which ensures greater fixation stability. Using a fixation compression plate without structural bone grafting can be an excellent choice for treating proximal humerus fractures in elderly patients over 80 years of age (53, 54). This can achieve radiological results similar to patients in the 67-79 age group. For elderly patients, especially those over the age of 80, surgical treatment can be challenging due to reduced overall endurance, increased risk of complications, and related factors. Using a compression plate without bone grafting can provide stable fracture fixation, promote faster

healing and restoration of shoulder function, and reduce the risk of complications associated with secondary intervention at the fracture site. Among all the above, the most distinctive study is the work of Wang et al. (55), in which the author depicted the course of metal screws and plates in a proximal shoulder fracture using a 3D model depending on the anatomical features. The modeling of pin placement through lateral and medial fixation and using the center of the dorsal olecranon curve as an anatomical reference point demonstrates a deep understanding of anatomy and extensive experience in this area. The approach to pin entry points based on the four quadrants established based on the center of the dorsal olecranon is also impressive in its systematic and logical approach. This avoids errors and ensures precise pin placement for optimal elbow reconstruction results.

There are several limitations to this study. Even with its significance, the sample size might not accurately reflect all demographic groups, especially the underrepresented younger populations. Furthermore, the very short follow-up time made it challenging to evaluate long-term results and potential issues later on. The fact that the study was limited to a single center may possibly have limited the findings' applicability in other clinical contexts.

The research aims to select configurations that are important for further development of this area of surgery. These configurations will help establish best practices and guidelines for use in real-world clinical situations. Supporting and rehabilitating people with disabilities, especially those with mobility limitations, is extremely important. Ensuring access to adaptive equipment and physical therapy programs helps improve these individuals' quality of life. Psychological support is also important for maintaining a positive attitude and self-esteem in people with limited mobility.

CONCLUSIONS

The study shows that due to the complexity of the injury and the need for precise surgical intervention, fractures of the proximal humerus, especially multiple fractures, present serious obstacles to treatment. The results show that a significant 83 % of the 346 patients who had proximal humerus fractures needed tendoplasty and reinsertion, underscoring the seriousness of these injuries and the urgent need for efficient surgical methods. Comparing the suggested method to conventional methods, it was found to be more effective in restoring anatomical integrity and functional outcomes. The method involves periosteal osteosynthesis employing anchor fixators and LCP plates.

This method, which combines stiff and elastic fixation, guarantees a solid attachment of bone fragments and tendons, facilitating appropriate healing and lowering the possibility of complications following surgery. The study's findings highlight the importance of choosing the right fixation techniques, especially when the rotator cuff and tendon-capsular apparatus are damaged. It has been demonstrated that using LCP plates and tendoplasty along with anchor fixation improves joint stability, facilitates functional recovery, and speeds up rehabilitation.

Due to the high success rate observed with this method, this technique should be considered a preferred alternative in the surgical treatment of complex proximal humerus fractures, especially in younger patients and elderly individuals who require significant upper limb functionality. This study shows that incorporating contemporary fixing procedures enhances patient outcomes and lowers the overall impairment linked to these kinds of accidents.

The results also indicate that further research and development in osteosynthesis will be necessary to improve the efficacy of surgical therapies for fractures of the proximal humerus. Further research should concentrate on improving these methods and determining whether they can be applied to a wider variety of musculoskeletal problems. This will enhance orthopedic surgical procedures in general and patient care.

Subsequent research endeavors ought to investigate the enduring consequences of the proposed surgical techniques across broader and diverse populations. Further study is needed to enhance the standards by which surgical candidates are selected and refine the surgical techniques to minimize issues and improve functional recovery.

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