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COMPLICATIONS OF PROXIMAL HUMERUS FRACTURES

KOMPLIKACIJE PRELOMA GORNJEG OKRAJKA RAMENICE

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Summary

Introduction. Proximal humerus fractures, resulting from direct or indirect trauma, pose a significant clinical challenge. The choice of surgical intervention is influenced by various factors including patient age, comorbidities, bone quality, activity level, fracture characteristics, and the surgeon's expertise. This study aims to assess the frequency and nature of complications arising from the surgical treatment of proximal humerus fractures. **Material and Methods.** In this retrospective analysis, 51 patients were included, with 22 males and 29 females. Two surgical techniques were employed: osteosynthesis using locking plates in 27 patients (average age 54.6 years) and intramedullary nailing in 24 patients (average age 58.4 years). The assessment of outcomes was conducted using the Constant Shoulder Score, and statistical analysis was performed using the Student's T-test. **Results**. Complications were observed in 12 patients (23.5%), comprising 7 males and 5 females. In the locking plate group, where 8 complications occurred, the mean Constant score was 77.44, while the intramedullary nail group, with 4 complications noted, had a mean Constant score of 70.25. No statistically significant difference was found in the incidence of complications based on gender or the type of surgical technique used. **Conclusion.** The study found a higher incidence of complications in male patients and those treated with locking plates, though these differences were not statistically significant. These findings emphasize the need for personalized surgical planning and highlight the complexity of managing proximal humerus fractures.

Key words: Humeral Fractures; Shoulder Fractures; Orthopedic Procedures; Fracture Fixation, Intramedullary; Fracture Fixation, Internal; Bone Plates; Postoperative Complications

Sažetak

Uvod. Prelomi proksimalnog humerusa, koji nastaju usled direktne ili indirektne traume, predstavljaju značajan klinički izazov. Izbor hirurške intervencije je pod uticajem različitih faktora uključujući starost pacijenata, komorbiditete, kvalitet kosti, nivo aktivnosti, karakteristike preloma i stručnost hirurga. Cilj ove studije bio je da se proceni učestalost i priroda komplikacija nakon hirurškog lečenja preloma proksimalnog humerusa. **Materijal i metode.** U ovu retrospektivnu analizu uključen je 51 pacijent, od kojih 22 muškaraca i 29 žena. Primenjene su dve hirurške tehnike: osteosinteza pomoću pločica na zaključavanje kod 27 pacijenata (prosečna starost 54,6 godina) i osteosinteza pomoću intramedularnog klina kod 24 pacijenta (prosečna starost 58,4 godine). Za procenu ishoda korišćen je *Constant* skor, a za statističku analizu primenjen je Studentov T-test. **Rezultati.** Komplikacije su uočene kod 12 pacijenata (23,5%), sa raspodelom od sedam muškaraca i pet žena. Prosečan *Constant* skor bio je 77,44 u grupi sa pločicama na zaključavanje, gde je zabeleženo osam komplikacija, i 70,25 u grupi sa intramedularnim klinom, sa četiri zabeležene komplikacije. Nije pronađena statistički značajna razlika u učestalosti komplikacija na osnovu pola ili vrste hirurške tehnike. **Zaključak.** Studija je pokazala veću učestalost komplikacija kod muškaraca i kod pacijenata lečenih pločicama na zaključavanje, iako ove razlike nisu bile statistički značajne. Ovi nalazi naglašavaju potrebu za individualizovanim hirurškim planiranjem i ističu složenost tretmana preloma proksimalnog humerusa.

Ključne reči: prelomi humerusa; prelomi ramena; ortopedske procedure; osteosinteza pomoću intramedularnog klina; osteosinteza pomoću zaključavajućih ploča; koštane pločice; postoperativne komplikacije

Introduction

Proximal humerus fractures result from either direct or indirect injury mechanisms. They frequently occur due to falls from a standing height, with road accidents being the second leading cause. Incidents involving electric shocks rarely contribute to such fractures [1]. Approximately 5% of all fractures are proximal humerus fractures [2]. Among individuals over 65 years of age, they rank third in frequency, following fractures of the distal radius and proximal femur [3]. The fracture rate shows exponential growth in the age groups 40-84 for women and 60-89 for men, and a ratio of women's fractures to men's being 2.3 to 1 [4]. The highest incidence is during the winter period, from November to March, and the lowest in September [5].

Codman [6] defined the four anatomical parts of the proximal humerus in 1934: head, lesser tuberosity, great tuberosity and shaft. Since then, many classifications of proximal humerus fractures have been introduced, with Neer's classification being the most often used [7]. Neer's classification categorizes proximal humerus fractures based on the number of dislocated segments.

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Abbreviations

CRPP – closed reduction and percutaneous pinning
ORIF – open reduction and internal fixation
HHR – humeral head replacement
IM – intramedullary

Treatment options for proximal humerus fractures are various, including conservative treatment, closed reduction and percutaneous fixation (CRPP), transosseous sutures, intramedullary pin fixation, open reduction and internal fixation (ORIF) and shoulder arthroplasty (HHR). Approximately 80% of fractures belong to the Neer 1 category and exhibit favorable functional outcomes with nonoperative treatment and early rehabilitation [8]. Vallier [9] notes that 3-part and 4-part fractures treated nonoperatively achieve satisfactory outcomes in only 10% of patients, so these types of fractures should be treated surgically in healthy, active individuals.

The choice of operative technique depends on the patient's age, comorbidities, bone quality, activity level, type of fracture, associated fractures, and the surgeon's technical ability.

Complications of proximal humerus fractures include post-traumatic shoulder stiffness and pain, avascular necrosis of the humeral head, nonunion fractures, fracture malunion, post-traumatic arthrosis, malposition of osteosynthetic material, superficial infection, deep infection, shoulder-hand syndrome, Sudeck's syndrome [10], rotator cuff injuries, vascular injuries, neurological injuries (injuries of the brachial plexus, axillary nerve, suprascapular nerve, radial nerve and musculocutaneus nerve), associated chest injuries, muscle calcifications, tendinitis of the shoulder muscles, osteoarthritis and subacromial impingement syndrome.

The objective of this study was to determine the percentage of complications associated with proximal humerus fractures, identify risk groups within age categories for the development of complications, indicate the most common mechanism of injury, determine the prevalence of each complication, determine the frequency of complications based on the type of treatment, and to explore whether there is a statistically significant difference in the frequency of complications based on gender.

Material and Methods

A retrospective study, conducted from June 2010 to August 2017, included 51 patients of both genders who had sustained proximal humerus fractures and underwent operative treatment. Participation in the study was voluntary, and the exclusion criteria comprised patients with open fractures, pathological fractures, or a history of previous shoulder surgery. Among the 51 patients analyzed, 22 were male (43.14%), and 29 were female (56.86%). The treatment modalities were divided between locking plate fixation in 27 patients (53%) and intramedullary nailing in 24 patients (47%). The average age of the cohort was 55.8 years. Specifically, patients treated with a locking plate had an average age of 54.6 years, while those who underwent intramedullary nailing had an average age of 58.4 years. The age range of the patients varied significantly, with the youngest being 28 years old and the oldest 77 years old.

Prior to sustaining their injuries, the patients' activity levels varied: 30 individuals (58.8%) were not engaged in any sports, 18 (35.3%) were recreational athletes, and 3 (5.9%) were professional athletes. The predominant mechanism of injury was a fall, accounting for 33 cases (64.7%). Traffic-related trauma caused injuries to 12 patients (23.5%), and 6 individuals (11.8%) sustained injuries during recreational activities. Information regarding diagnoses, injury dates, and surgical interventions was meticulously gathered from the patients' medical records. The outcomes of the treatments were evaluated during follow-up examinations.

The osteosyntheses in this study were performed using either the Stryker AxSOStm locking plate system or the Stryker T2 proximal humeral nailing system. Prophylactic measures included administering first-generation intravenous cephalosporins immediately before surgery, with antibiotic prophylaxis continuing for a total of 48 hours. All procedures were performed under general anesthesia, supplemented by regional block anesthesia, and were performed by the same surgeon.

Patients were positioned on a radiolucent table in a semi-sitting (beach-chair) position, with the headboard elevated at an angle of 35°-45°. The body alignment along the table edge facilitated the shoulder to cross over, ensuring a full range of motion of the operated arm during surgery.

For osteosynthesis using a locking plate, a deltopectoral approach was consistently employed. The surgical procedure began with a skin incision approximately 10 cm in length, starting 1 cm laterally from the coracoid process tip and extended proximally to the deltoid tuberosity. During this approach, careful attention was given to identify key neurovascular structures, particularly the axillary and musculocutaneous nerves. Fragment repositioning was carried out, and Kirschner pins were temporarily used if needed for stabilization. The locking plate was positioned, ensuring that its proximal end was located 5-10 mm lateral to the intertubercular sulcus and 15-20 mm distal to the greater tubercle's apex. Prior to screw insertion, the plate's placement was verified through X-ray imaging. After screw placement, the rotator cuff tendons were secured to the plate. A final X-ray confirmed the accurate positioning of the plate and screws, after which the wound was closed in layers.

In cases of intramedullary (IM) nailing, a minimally invasive anterolateral approach was employed. A 3 cm longitudinal incision was made anterolaterally from the acromion, with the deltoid muscle split along its fibers. The entry point for the nail was created just medial to the greater tubercle and 1.5 cm posterior to the bicipital groove. Following fracture repositioning and fixation, the incision was similarly closed in layers. To ensure the accuracy of fracture repositioning and the proper placement of the osteo-

synthetic material, radiographic confirmation was obtained using a mobile X-ray unit.

Postoperative care for all patients included immobilization of the upper arm at 45° abduction, the elbow at 90° flexion, and the forearm in a neutral position, lasting for a period ranging from 4 to 6 weeks. The duration of immobilization was individualized depending on the factors such as fracture type, patient age, success of repositioning, and stability of fixation. Passive movements in the elbow of the operated arm were initiated from the onset of immobilization. Starting from the second week, passive shoulder movements were introduced and continued until the immobilization was removed. Upon removal, physical therapy commenced to facilitate the regaining of full range of motion.

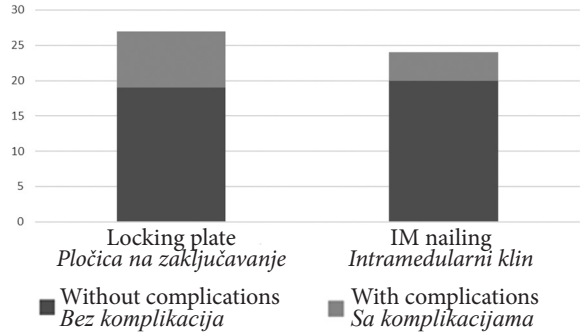
Follow-up assessments included postoperative X-rays taken on the 10th day after surgery, as well as at 3 and 6 weeks, and subsequently at 3 and 6 months. The average follow-up period extended over 4 years, ranging from 1 to 9 years. The well-established Constant score [11] was used to evaluate treatment outcomes. This scale allocates 35 points to subjective parameters, including pain (15 points) and quality of life (20 points), while the remaining 65 points are based on objective measurements of range of motion (40 points) and shoulder strength (25 points), resulting in a maximum score of 100 points.

All patients were overseen by the same surgeon who had performed their respective operations. Any development of complications was documented throughout follow-up visits. Statistical analysis of patient data with use of the Student's T-test was undertaken to identify correlations between different variables and the occurrence of complications.

Results

The study included 51 patients, and complications were observed in 12 participants (23.5%). Among the 22 male patients, 7 encountered complications, while 5 out of the 29 female patients also experienced complications. However, the difference in complication rates between genders was not statistically significant ($p > 0.05$).

Among the 27 patients who underwent osteosynthesis with a locking plate, 8 (29.6%) experienced complications. These complications included superficial infection in 2 patients (7.4%), osteonecrosis of the humeral head in 3 (11.1%), chronic pain in 4 (14.8%), and reduced range of motion in 6 (22.2%) patients. Within this subset, 3 patients could raise their arm above shoulder level, 2 up to shoulder level, and 1 had very limited mobility, below shoulder level. It is noteworthy that the patient with severely limited mobility had a history of forearm surgery 25 years prior, resulting in an elbow joint contracture.



Graph 1. Prevalence of complications depending on the operative technique
Grafikon 1. *Zastupljenost komplikacija zavisno od operativne tehnike*

In the group of 24 patients treated with intramedullary nailing, complications occurred in 4 patients (16.7%). This included chronic pain in all 4 patients, migration of osteosynthetic material in 3 (12.5%), and one of these three also had a reduced range of motion, managing 80° abduction and 50° flexion.

The frequency of complications between the two groups – those operated with locking plates and those with intramedullary nailing – showed no statistically significant difference ($p > 0.05$), as illustrated in **Graph 1**.

When evaluating treatment outcomes using the Constant score, the locking plate group had 33.3% of patients with excellent results, 22.2% with good results, 14.8% with satisfactory results, and 29.6% with poor results. In contrast, the intramedullary nail group had 29.2% of patients with excellent results, 16.7% with good results, 12.5% with satisfactory results, and 41.6% with poor results. The average Constant score [11] was 77.44 for the locking plate group and 70.25 for the intramedullary nail group. Once again, no statistically significant difference ($p>0.05$) was found in the Constant score between the two groups, as detailed in **Table 1.**

Table 1. Results of Constant score by group
Tabela 1. *Vrednost Constant skora po grupama*

	Locking plate/*Pločica na zaključavanje*	IM nail/*Intramedularni klin*	Total/*Ukupno*
Excellent/*Odličan*	9 (33.3%)	7 (29.2%)	16
Good/*Dobar*	6 (22.2%)	4 (16.7%)	10
Satisfying/*Zadovoljavajući*	4 (14.8%)	3 (12.5%)	7
Poor/*Lošš*	8 (29.6%)	10 (41.6%)	18
Average/*Prosečan*	77.44	70.25	74.06
Total/*Ukupno*	27	24	51

Discussion

Proximal humerus fractures are subject to surgical treatment in approximately 15.7% of cases [12]. The primary goal of these operative treatments is to secure stable fixation, enabling the prompt initiation of shoulder movement and early rehabilitation. Despite the increasing incidence of proximal humerus fractures, attributed to an aging population and a rise in osteoporosis cases, no single surgical technique has emerged as definitively superior. Consequently, advocating for a tailored approach for each patient is emphasized.

In our study, the average age of patients undergoing surgery with a locking plate was 54.6 years, compared to 58.4 years for those receiving intramedullary nailing. This finding is consistent with other research, where the average age for patients treated with a locking plate ranged from 59 to 71 years [13–16], and from 48 to 64.8 years for those treated with intramedullary nailing [13, 15, 17, 18]. Our study also noted a higher prevalence of proximal humerus fractures in women, with females constituting 57% of our patient group. This percentage is consistent with other studies, where female representation varied between 40% and 83% [14–17].

Regarding complications and outcomes, among the 27 patients in our study treated with a locking plate, 8 (29.6%) experienced complications. The average Constant score in this group was 77.44. This result is comparable to the findings of Ockert et al., who reported an average Constant score of 75.3, assessed 10 years post-operation with a locking plate, further corroborating our study's results [16].

Schliemann et al. recorded complications in 59% of patients treated with a locking plate, which is a higher percentage compared to our study [14]. It's important to note that their study exclusively involved participants over the age of 65. Lekic et al. observed complications in 33% of their patients [15], closely aligning with our results, while Ricchetti et al. reported a lower complication rate of 18.5% [19].

In contrast to Clavert et al., who found a 16.4% incidence of avascular necrosis of the humeral head in patients treated with a locking plate, our study observed this complication in 11.1% of cases [20]. Avascular necrosis is more common in comminuted fractures, and any dislocation can increase the risk of vascular supply damage to the humeral head. The pathophysiology behind this condition remains not fully understood, as osteonecrosis can occur even in minimally dislocated or non-dislocated fractures, and may not develop in cases where the head is deprived of blood supply [21]. Notably, even when osteonecrosis develops, patients may not experience significant issues if the greater tubercle is well-repositioned and healed, given that the shoulder joint does not bear body weight.

Sudkamp et al. reported a 19% rate of revision surgery following osteosynthesis with a locking plate [22], Ockert et al. noted 14% [16], and Schiliemann et al. observed 29.6% [14]. In our study, none of the patients required revision surgery. Indications for such surgeries in these studies included osteonecrosis, primary or secondary cutout, loss of fixation, and post-traumatic arthritis. Among these, we only encountered osteonecrosis in our study. However, patients with humeral head osteonecrosis often maintain satisfactory shoulder function and thus do not necessitate revision surgery.

Our research also included 24 patients treated with an intramedullary nail, where complications arose in 4 (16.7%) cases, and the average Constant score was 70.25. In a study by Linhart et al. among patients operated with an intramedullary nail, the mean value of the Constant score was 78.4, which is slightly higher than the mean value in our study, but not significantly [23]. Both our study and theirs fall into the „good" category of the Constant score. Similar to our findings, Boileau et al. [18] also did not have any patients requiring revision surgery. All fractures in their study healed, and patients regained sufficient range of motion for daily activities postoperatively. Their average Constant score was 69, aligning closely with our results.

The study conducted by Lekic et al. on patients treated with intramedullary nailing reported a 42% complication rate [14], while Agel et al. observed complications in 45% of their patients [17]. These figures are higher than those in our study. It is important to note that, in our research, any deviation from a complete return to pre-injury shoulder function was classified as a complication. However, complications do not always equate to poor outcomes or necessitate revision surgery. Particularly for elderly patients, a reduction in function may not be significantly problematic as long as they can perform daily activities without pain.

Our study found no statistically significant differences in outcomes or Constant scores between the locking plate and intramedullary nail groups, a finding echoed by Von Ruden et al. who reported Constant scores of 73 and 72 in these groups, respectively [24].

In our patient cohort, 29.6% of those treated with a locking plate experienced complications, compared to 16.7% in the intramedullary nail group. This difference was not statistically significant, aligning with the findings of Konrad et al., who also reported no significant difference in complication rates between these two groups (31% in the locking plate group and 21% in the intramedullary nail group) [13].

The overall benefit of operative treatment for proximal humerus fractures is substantial, with the complications observed in our study having minimal impact on patients' quality of life. Without operative intervention, these injuries could have led to severe disability. It is also noteworthy that the Constant score, while useful for assessing shoulder function, may not fully reflect a patient's quality of life. Many patients with a low Constant score still maintain satisfactory function and can perform daily activities. The distinction between objective and subjective assessments of shoulder hemiarthroplasty outcomes can be clarified by considering the impact of post-surgery range of motion on daily

activities. The majority of everyday tasks are accomplished at scapular level, involving 80 to 90 degrees of abduction and external rotation. In this range, functional outcomes are generally satisfactory for normal activities of daily living. However, activities requiring maximum abduction and flexion (180 degrees) represent a smaller portion, contributing to the variation in subjective evaluations, as they may not align with the overall functional success indicated by objective measures [25]. Furthermore, our study encompassed all types of fractures, including severe cases that would likely have resulted in significant disability if left untreated.

However, there are limitations to our study. These include a small sample size, the lack of subdivision of patients according to Neer's classification for individual evaluation, and its retrospective nature. Another limitation is the heterogeneity between the locking plate and intramedullary nail groups in terms of fracture type, patient gender, and age. Additionally, comparing our data with other studies [13–20, 22–24] is challenging due to variations in fracture types, patient demographics, follow-up duration, and study inclusion criteria.

Conclusion

Based on the analysis of the results from this study and a review of the literature, the following conclusions can be drawn:

– Proximal humerus fractures are predominantly observed in the elderly population.

– Although complications were observed more frequently in men, the difference was not statistically significant.

– Patients treated with osteosynthesis using a locking plate experienced more complications compared to those treated with intramedullary nailing, but this difference was not statistically significant.

– The Constant score was marginally higher in the group treated with a locking plate, but this difference did not reach statistical significance.

– It is important to note that the Constant score, while useful for assessing shoulder function, may not be the most accurate indicator of a patient's overall quality of life. This is because many patients with a lower Constant score still maintain satisfactory function and are able to perform daily activities without experiencing pain.

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