Manual Therapy, Posturology & Rehabilitation Journal

RESEARCH ARTICLE

Recovery of shoulder range of motion after proximal humerus fracture: A quantitative research on rehabilitation progression, gender differences and the prognostic value of initial mobility

Denis Arsovski, Haris Amedovski

University St. Kliment Ohridski Bitola, Higher medical school – Bitola, North Macedonia

Abstract

Background: Proximal humerus fractures are the most common upper limb injuries, affecting the mobility of the shoulder, affecting independence, and quality of life, especially in older adults. Rehabilitation is very important in functional recovery and in preventing chronic disability. **Objective:** To analyze the duration and progression of range of motion recovery after conservative treatment of proximal humerus fractures and to examine the influence of gender and initial range of motion on rehabilitation. **Method:** A quantitative, observational research was conducted on eight patients (four male, four female) from 45 to 65 years who went on a structured 12-week rehabilitation program divided into four phases. Range of motion was assessed at the start and at 4, 8, and 12 weeks with a goniometer. Descriptive statistics were used to summarize mean values and progression across phases. Repeated measures analysis of variance was applied to examine changes in range of motion over time, and an independent samples t-test was used to compare gender differences. The level of significance was set at $p < 0.05$. **Results:** Notable improvements were observed across all shoulder movements ($p < 0.05$). Functional elevation, abduction, and extension were restored by week 8-12, while internal and external rotations showed slower recovery. There were no statistically significant gender differences in the time to achieve full range of motion. However, a lower initial range of motion correlated with prolonged rehabilitation duration, indicating prognostic importance. **Conclusion:** A phased and standardized rehabilitation protocol is effective for restoring full shoulder range of motion within 6-12 weeks after non-operative proximal humerus fractures. Gender does not influence recovery outcomes, while initial range of motion serves as important predictor of rehabilitation duration, supporting individualized rehabilitation planning.

Keywords: Proximal humerus fractures; shoulder joint; range of motion, articular; rehabilitation; physical therapy modalities.

Corresponding author: Denis Arsovski

Email: denis.arsovski@uklo.edu.mk

Received: 08 Out, 2025
Accepted: 02 Mar, 2026
Published: 09 Mar, 2026

BACKGROUND

Proximal humerus fractures are among the most frequent injuries on upper limb, especially frequent in the elderly population[1]. The growing prevalence of these fractures correspond with the global aging trend[2]. Typically caused by falls or trauma, these injuries cause reduction in the range of motion of the shoulder, functional capacity, and quality of life[3].

In addition to the direct physical consequences, these limitations can impair the ability of persons to perform activities of daily living, causing loss of independence and psychological distress[4].

These fractures involve the upper segment of the humerus and may extend into the shoulder joint itself[5]. Depending on the displacement, complexity, and involvement of surrounding tissues, either nerves or cartilage, they are categorized into different types, from non-displaced to complex comminuted fractures[6]. Treatment choice - conservative or surgical impacts the rehabilitation process and the eventual restoration of shoulder function[7]. Conservative treatment is preferred in non-displaced fractures, involving shoulder immobilization through a sling or cast[8]. In contrast, surgical interventions such as internal fixation with plates and screws are necessary for displaced or unstable fractures[9].

Rehabilitation after proximal humerus fracture is essential for recovery, with the primary objective of restoring full range of motion, minimizing pain, and restoring strength and neuromuscular control[10, 11]. Clinical data suggest that the time required for functional recovery vary between patients, influenced by factors like age, comorbidities, gender physiological differences, hormonal status, bone density, and muscle mass[12]. It's important to consider gender-based physiological variations in recovery[13]. Women, especially postmenopausal are more susceptible to these kind of fractures because of the lower bone mineral density and the presence of osteoporosis[14]. Hormonal fluctuations, especially reduced estrogen levels are well known to delay bone healing and muscle recovery[15]. On the other hand, men possess higher muscle mass and bone density, which may provide a modest advantage in terms of recovery speed and functional outcomes after rehabilitation[16].

The rehabilitation process is structured into several phases, from passive mobilization during the early immobilization phase to active, resistance, and functional training in later stages[17]. Each phase is individualized to the healing stage of the fracture and the individualized progress of the patient[18]. Physiotherapy techniques include not only physical exercises but also the use of different rehabilitation modalities such as ultrasound therapy, cryotherapy, interferential currents, and continuous passive motion devices[19, 20]. In practice, range of motion is one of the most important measures used to evaluate the success of rehabilitation[21]. Functional range of motion restoration correlates with improved independence and psychosocial well-being[22].

The objective of this research is to analyze the duration and progression of range of motion recovery in patients who went rehabilitation after proximal humerus fractures. This research paper seeks to find the average time required to achieve full range of motion in specific shoulder movements, to examine differences in recovery dynamics between male and female patients to compare the collected data with global rehabilitation standards and to evaluate the influence of gender-specific factors and initial range of motion on the rehabilitation.

METHODS

This research paper was designed as a retrospective, observational, and experimental analysis conducted to evaluate the recovery dynamics of patients with proximal humerus fractures after structured rehabilitation. The primary aim was to quantify the time required to achieve full range of motion in six shoulder movements, assess differences based on gender, and evaluate the prognostic role of initial range of motion.

Participants

Twelve adult patients (45-65 years) who sustained a proximal humerus fracture and went on non-operative rehabilitation were initially enrolled. The final sample included eight participants (four male and four female) after applying exclusion criteria: prior surgical intervention, endoprosthetic implantation, or structural impairments that would preclude achieving full range of motion. All participants gave informed consent for the anonymized use of their clinical data in research.

Data collection and range of motion assessment

Range of motion was measured with a goniometer by licensed physiotherapists at four time points. Elevation (0–180°), extension (0–50°), abduction (0–150°), adduction (0–30°), internal rotation (0–85°) and external rotation (0–90°) were assessed. All ranges of motion values were recorded in degrees and compared to standardized clinical standards for full functional mobility. Data were organized into recovery timelines per movement and analyzed based on gender and initial range of motion values.

Rehabilitation protocol

Each patient followed a standardized rehabilitation protocol designed by a specialist in physical medicine and implemented under the supervision of a physiotherapist. The protocol consisted of four phases. In the first phase (acute phase, from 0-3 weeks), passive exercises within the pain free range of motion was used, cryotherapy for inflammation and pain control.

In the second phase, (subacute phase, 3-6 weeks), active exercises without resistance for improving range of motion were used, pendulum and shoulder plane-specific movements, isometric strengthening to prevent muscle atrophy and gentle mobilization and assisted stretching. In the third phase (functional phase, 6-9 weeks), eccentric and hypertrophy including exercises were used, functional training using resistance bands, exercise wheels, hand ergometers, and stairs, electrical muscle stimulation to re-educate and strengthen shoulder musculature and ultrasound therapy to support tissue repair. In the fourth phase (maintenance phase, 9-12 weeks) proprioceptive and neuromuscular training was used, strength and endurance-focused routines, return-to-function exercises individualized to patient needs and patient education for joint protection and self-management. The protocol was individualized according to the healing phase, pain, and progress of each patient.

Statistical analysis

Descriptive statistics were used to summarize the mean values and progression of shoulder range of motion among the four rehabilitation phases. Changes in range of motion over time were analyzed using repeated measures analysis of variance to determine statistically significant improvements between the measurement points (weeks 0, 4, 8, and 12). Additionally, an independent samples t-test was performed to compare gender-related differences in recovery time and initial elevation range of motion. Statistical significance was set at $p < 0.05$.

Ethical considerations

This research paper was conducted in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki declaration and its later amendments. Ethical review was waived due to the retrospective nature of the research and the use of anonymized data. All procedures performed were part of routine patient care.

RESULTS

Table 1. Progression of elevation range of motion (0–180°)

Patient ID	Gender	Start ROM (°)	4 weeks (°)	8 weeks (°)	12 weeks (°)
1	F	90	160	180	/
2	F	110	130	160	180
3	M	120	160	160	180
4	F	100	130	180	/
5	M	30	120	180	/
6	M	140	180	/	/
7	F	100	180	/	/
8	F	130	180	/	/
Mean	/	**90.00**	**145.00**	**168.57**	**180.00**

Table 1 shows the progression of shoulder flexion (elevation) range of motion in degrees across time points (initial - start, 4 weeks, 8 weeks, and 12 weeks) during the rehabilitation process for patients with proximal humerus fractures. Out of eight patients, gender is equally represented. The average initial range of motion was 90.0°, improving to 145.0° at 4 weeks, and reaching 168.6° by 8 weeks, with further improvement in some patients to 180.0° by 12 weeks, which represents full range of motion. Female patients showed a generally higher starting range of motion (average ~107.5°) compared to male patients (~96.7°), potentially due to known sex-based joint flexibility differences.

The most important progression was seen in patient 5, who started with a reduced range of motion of 30° and progressed to full range of motion within 8 weeks, showing exceptional rehabilitation. Patients 6, 7 and 8 reached full range of motion by 4 weeks, suggesting that early recovery may be associated with either less severe injury or excellent adherence to therapy protocols.

Table 2. Progression of extension range of motion (0–50°)

Patient ID	Gender	Start ROM (°)	4 weeks (°)	8 weeks (°)	12 weeks (°)
1	F	30	50	/	/
2	F	30	40	40	50
3	M	40	40	40	50
4	F	30	40	50	/
5	M	20	40	50	/
6	M	40	50	/	/
7	F	50	/	/	/
8	F	20	50	/	/
Mean	—	**33.75**	**43.33**	**44.00**	**50.00**

Table 2 shows the rehabilitation progress of shoulder extension in degrees for patients recovering from proximal humerus fractures. The average initial range of motion was 33.75°, increasing to 43.33° by 4 weeks, and to 44.0° at 8 weeks, with limited data at 12 weeks showing an average of 50.0°, which is the full range of motion. Patients 3 and 2 showed steady progression with full recovery by 12 weeks.

Patient 1 achieved full extension as early as 4 weeks post-injury. In contrast, patient 5 began with the lowest initial range of motion (20°) but improved to full range of motion by week 8. Data from 7 was incomplete, but she started with the highest initial extension ROM (50°), suggesting minimal functional limitation at baseline. These results show that most patients reached or approached full extension range of motion within 8 weeks. Early improvement (by week 4) appears common, especially among females, possibly due to initially higher flexibility or lower injury severity.

Table 3. Progression of abduction range of motion (0–150°)

Patient ID	Gender	Start ROM (°)	4 weeks (°)	8 weeks (°)	12 weeks (°)
1	F	60	90	130	150
2	F	90	100	120	150
3	M	60	80	150	/
4	F	80	90	150	/
5	M	40	80	150	/
6	M	90	130	150	/
7	F	90	150	/	/
8	F	90	150	/	/
Mean	/	**76.25**	**110.00**	**138.75**	**150.00**

Table 3 shows the recovery of shoulder abduction in degrees, a key functional movement affected by proximal humerus fractures. The assessments were taken at start and then at 4, 8, and 12 weeks into rehabilitation. The average starting range of motion was 76.25°, progressing to 110.0° at 4 weeks, and further improving to 138.75° at 8 weeks.

At 12 weeks, patients who were measured had reached full range of motion (150°), indicating successful rehabilitation. Patient 7 and 8 showed rapid recovery, achieving full range of motion already by 4 weeks. Patients 3, 4 and 5 also showed complete abduction range of motion by week 8, despite lower initial range of motion (as low as 40°). Patient 6 had an accelerated progression, reaching 130° by 4 weeks.

Table 4. Progression of adduction range of motion (0-30°)

Patient ID	Gender	Start ROM (°)	4 weeks (°)	8 weeks (°)	12 weeks (°)
1	F	30	/	/	/
2	F	30	/	/	/
3	M	30	/	/	/
4	F	0	30	/	/
5	M	10	20	30	/
6	M	30	/	/	/
7	F	30	/	/	/
8	F	30	/	/	/
Mean	/	**26.25**	**25.00**	**30.00**	/

Table 4 shows the progression in shoulder adduction (0–30°) for patients included in this research. Adduction is often preserved or quickly restored. Most patients (6 out of 8) started with full range of motion (30°) and required no further rehabilitation for this movement. Only two patients, 4 and 5, showed incomplete range of motion at start, progressing to full range of motion by the 4th and 8th week, respectively. The mean initial range of motion was 26.25°, with nearly all patients at or close to full range of motion by the end of week 8.

Table 5. Progression of internal rotation range of motion (0–85°)

Patient ID	Gender	Start ROM (°)	4 weeks (°)	8 weeks (°)	12 weeks (°)
1	F	20	45	85	/
2	F	40	45	60	85
3	M	0	20	35	85
4	F	0	70	85	/
5	M	/	/	/	/
6	M	50	85	/	/
7	F	/	/	/	/
8	F	85	/	/	/
Mean	/	**32.5**	**44.17**	**66.25**	**85.00**

Table 5 shows the progress in internal shoulder rotation (0-85°), a complex movement often delayed in recovery due to rotator cuff involvement. Initial range of motion averaged 32.5° among those measured, increasing to 44.17° at 4 weeks, and further to 66.25° by 8 weeks.

The patients who reached 12-week assessment all achieved full range of motion (85°). Patients 4 and 1 showed the largest improvements, both recovering from 0–20° to full range within 8 weeks. Missing data for 5 and 7 reflects contraindications related to structural shoulder damage.

Table 6. Progression of external rotation range of motion (0–90°)

Patient ID	Gender	Start ROM (°)	4 Weeks (°)	8 Weeks (°)	12 Weeks (°)
V.J.	F	30	50	90	/
G.L.	F	50	60	70	90
G.G.	M	0	20	45	90
J.K.	F	0	50	90	/
B.R.	M	/	/	/	/
V.T.	M	80	90	/	/
M.D.	F	/	/	/	/
S.G.	F	40	90	/	/
Mean	/	**33.33**	**52.86**	**73.75**	**90.00**

Table 6 shows external shoulder rotation (0-90°), a movement that is often delayed due to capsular and muscular tightness. The average starting range of motion was 33.33°, improving to 52.86° at 4 weeks, and 73.75° by 8 weeks. All patients who reached 12 weeks achieved full range of motion (90°). Patients 3 and 4 made dramatic improvements from 0° at baseline to full range of motion by week 8 or 12. Patients 6 and 8 reached full range of motion by week 4. The results from this table confirm that external rotation improves by week 8–12, but may require prolonged and focused rehabilitation compared to other shoulder movements.

Table 7. Repeated analysis of variance for range of motion progression across rehabilitation phases

Movement	F-Statistic	p-Value
Elevation	14.90	0.0006
Extension	7.00	0.0147
Abduction	25.70	0.0000
Internal rotation	5.87	0.0234
External rotation	6.40	0.0187

Table 7 shows the results of repeated analysis of variance used to analyze shoulder range of motion improvement among the three rehabilitation stages. The analysis was conducted separately for each functional movement of the shoulder. All five movements showed statistically significant improvement over time, as all p-values are less than 0.05. Abduction showed the greatest improvement (F = 25.70), followed by elevation (F = 14.90), which are important indicators of shoulder function restoration. Rotational movements also showed progression, although with slightly lower F-values, indicating a more gradual recovery direction.

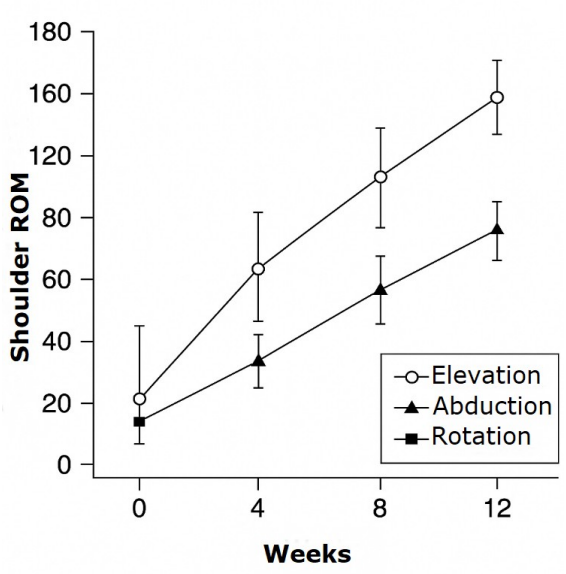

Figure 1. Time to full range of shoulder movement

Figure 1 shows the progression of shoulder range of motion over a 12-week rehabilitation period after proximal humerus fracture. Measurements were taken at baseline and after 4, 8, and 12 weeks. Significant improvements were seen in elevation, abduction, and rotation. Error bars represent standard deviations. Data are presented in degrees and expressed as mean ± standard deviation.

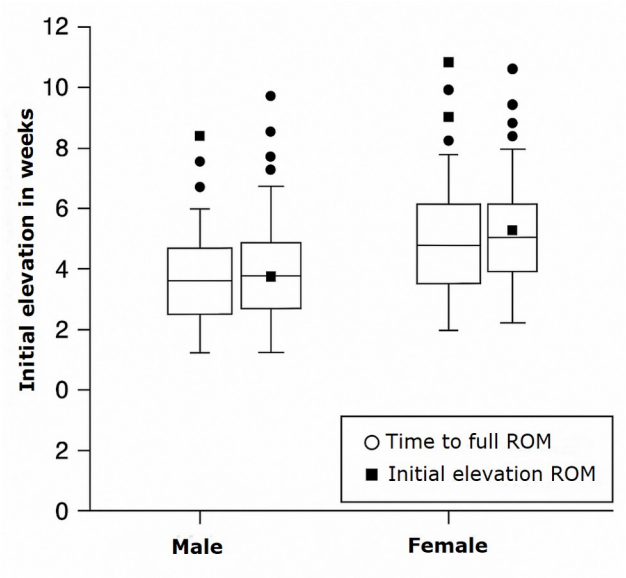

Figure 2. Comparison of time to full range of motion and initial elevation range of motion by gender

Figure 2 is showing the comparison between males and females in time to achieve full shoulder range of motion and initial elevation range of motion after proximal humerus fracture rehabilitation.

DISCUSSION

This research aimed to evaluate the time and progression required to restore full range of motion in patients in rehabilitation for proximal humerus fractures, while also examining the influence of gender and initial range of motion on recovery outcomes. The results showed improvements in all measured shoulder movements for the 12-week rehabilitation, confirming the effects of the standardized physiotherapeutic protocol. Also, despite biological and functional differences, no statistically significant gender-based differences were observed in recovery time, while initial range of motion appeared to have a more prominent role in predicting rehabilitation duration. These results are discussed in the context of current literature, clinical expectations, and implications for individualized rehabilitation strategies.

The results of our research showed that full range of motion in shoulder movements such as elevation, abduction, and extension was commonly restored within 6 to 12 weeks of structured rehabilitation, even in non-operatively managed proximal humerus fractures. This recovery time is consistent with the case study[23], in which a patient with a surgically treated three-part fracture regained approximately 80% of range of motion at 12 weeks following anatomical realignment using a locking plate and CT-based range of motion simulation.

While this research shows the utility of pre-and post-operative motion simulation in guiding treatment decisions, our research shows that comparable functional outcomes may be achievable through standardized physiotherapeutic protocols without surgical intervention in appropriately selected cases. As noted in our results, patients who reached 12-week assessment all achieved full range of motion, this suggests that conservative rehabilitation protocols can define outcomes in terms of functional mobility, comparable to post-surgical recovery under certain fracture classifications and patient profiles.

Also, this research confirms the effects of a standardized, phase rehabilitation protocol in restoring full shoulder range of motion within 6 to 12 weeks after non-surgical management of proximal humerus fractures. These results align partially with one research[24] which integrated proprioceptive neuromuscular facilitation, capacitive resistive electric transference, kinesiological taping, and PRAMA technology, our study shows that functional gains are still achievable through a simplified, yet structured protocol relying on traditional modalities such as passive/active range of motion, EMS, ultrasound therapy, and resistance training.

A structured, four-phased rehabilitation protocol can result in the complete restoration of shoulder range of motion within 6-12 weeks in patients recovering from proximal humerus fractures treated conservatively. This outcome compares favorably with the quasi-experimental study[25], where rehabilitation exercises post-surgery improved shoulder function and reduced pain based on validated scoring systems ($p = 0.0179$ for function and $p = 0.003$ for pain). Despite differences in treatment approach, surgical vs. non-surgicalboth researches define the role of individualized rehabilitation in functional recovery.

While one study[26] showed that reverse total shoulder arthroplasty offered superior long-term outcomes compared to open reduction internal fixation for complex geriatric proximal humerus fractures, our results suggest that non-operative management using a structured rehabilitation protocol can restore full range of motion within 6 to 12 weeks, especially in non-complex fracture types.

Limitations and future directions

Despite the encouraging results observed in this research, several limitations should be acknowledged. First, the sample size was relatively small (n=8) due to strict inclusion criteria, which limits the generalizability of the results. Although gender representation was balanced, the low number of participants restricted the statistical power for detecting subtle differences in recovery dynamics and prevented stratification based on age or fracture severity.

The research was conducted in a single-center environment – clinical hospital Dr. Trifun Panovski in Bitola, North Macedonia and all patients went on non-operative rehabilitation, meaning that results may not apply to surgically treated patients or those with more complex fracture types. While range of motion was measured quantitatively with a goniometer, other critical functional outcomes such as strength testing, pain scores, patient satisfaction, or validated functional indices were not included. These could have provided a more holistic view of the effects of rehabilitation.

In terms of future directions, studies with larger sample sizes and multicenter designs are recommended to validate these results across various populations. Incorporating longer follow-up durations would allow for the evaluation of long-term shoulder function, recurrence of limitations, or post-rehabilitation quality of life. Comparative studies between non-operative rehabilitation, modern technology-based protocols, and surgical approaches should also be followed to determine optimal care for various fracture types and patient demographics. Also, future protocols will benefit from the integration of digital rehabilitation tools, tele-rehabilitation systems, or wearable sensors to monitor progress in real time and individualize recovery plans more precisely.

Author Contributions: D.A.: Conceptualization, investigation, resources, writing – original draftpreparation, project administration. H.A.: Investigation, resources.

Financial Support: This work did not receive financial support from public, private or non-profitfunding agencies.

Conflict of interest: The authors declare that there are no conflicts of interest related to this study.

REFERENCES

1. PATEL, A. H., WILDER, J. H., OFA, S. A., et al. Trending a decade of proximal humerus fracture management in older adults. JSES International. 2021, 6(1), 137–143. Dostupné online: https://doi.org/10.1016/j.jseint.2021.08.006
2. RELVAS SILVA, M., LINHARES, D., LEITE, M. J., et al. Proximal humerus fractures: Epidemiology and trends in surgical management of hospital-admitted patients in Portugal. JSES International. 2022, 6(3), 380–384. Dostupné online: https://doi.org/10.1016/j.jseint.2021.12.003
3. IKING, J., FISCHHUBER, K., STOLBERG-STOLBERG, J., et al. Quality of Life and Pain after Proximal Humeral Fractures in the Elderly: A Systematic Review. Medicina. 2023, 59(10), 1728. Dostupné online: https://doi.org/10.3390/medicina59101728
4. HANDOLL, H. H., ELLIOTT, J., THILLEMANN, T. M., et al. Interventions for treating proximal humeral fractures in adults. The Cochrane Database of Systematic Reviews. 2022, 6(6), CD000434. Dostupné online: https://doi.org/10.1002/14651858.CD000434.pub5
5. BAKER, H. P., GUTBROD, J., STRELZOW, J. A., et al. Management of Proximal Humerus Fractures in Adults—A Scoping Review. Journal of Clinical Medicine. 2022, 11(20), 6140. Dostupné online: https://doi.org/10.3390/jcm11206140
6. BAO, M. H., DEANGELIS, J. P., WU, J. S. Imaging of traumatic shoulder injuries – Understanding the surgeon's perspective. European Journal of Radiology Open. 2022, 9, 100411. Dostupné online: https://doi.org/10.1016/j.ejro.2022.100411
7. MARTINEZ-CATALAN, N. Conservative treatment of proximal humerus fractures: When, how, and what to expect. Current Reviews in Musculoskeletal Medicine. 2023, 16(2), 75–84. Dostupné online: https://doi.org/10.1007/s12178-022-09817-9
8. BAKER, H. P., GUTBROD, J., CAHILL, M., et al. Optimal treatment of proximal humeral fractures in the elderly: Risks and management challenges. Orthopedic Research and Reviews. 2023, 15, 129–137. Dostupné online: https://doi.org/10.2147/ORR.S340536
9. BERKES, M. B., LITTLE, M. T., LORICH, D. G. Open reduction internal fixation of proximal humerus fractures. Current Reviews in Musculoskeletal Medicine. 2013, 6(1), 47–56. Dostupné online: https://doi.org/10.1007/s12178-012-9150-y
10. SINGLETON, E., TURNER, R., GULOTTA, L. Rehabilitation after proximal humeral fractures. Techniques in Shoulder & Elbow Surgery. 2014, 15(1), 46–50. Dostupné online: https://doi.org/10.1097/BTE.0000000000000013
11. HODGSON, S. Proximal humerus fracture rehabilitation. Clinical Orthopaedics and Related Research. 2006, 442, 131–138.
12. KATTHAGEN, J. C., RASCHKE, M. J., FISCHHUBER, K., et al. Conservative versus operative treatment of proximal humerus fractures in older individuals. Deutsches Ärzteblatt International. 2024, 121(14), 454–460. Dostupné online: https://doi.org/10.3238/arztebl.m2024.0059
13. EZUMA, C. O., KOSBER, R. L., KOVACEVIC, D. Biological sex impacts perioperative complications after reverse shoulder arthroplasty for proximal humeral fracture. JSES International. 2021, 5(3), 371–376. Dostupné online: https://doi.org/10.1016/j.jseint.2020.12.005
14. TASKESEN, A., GÖÇER, A., UZEL, K., et al. Effect of osteoporosis on proximal humerus fractures. Geriatric Orthopaedic Surgery & Rehabilitation. 2020, 11, 2151459320985399. Dostupné online: https://doi.org/10.1177/2151459320985399
15. CHIDI-OGBOLU, N., BAAR, K. Effect of estrogen on musculoskeletal performance and injury risk. Frontiers in Physiology. 2019, 9, 1834. Dostupné online: https://doi.org/10.3389/fphys.2018.01834

16. PATEL, A. H., WILDER, J. H., OFA, S. A., et al. How age and gender influence proximal humerus fracture management in patients older than fifty years. JSES International. 2021, 6(2), 253–258. Dostupné online: https://doi.org/10.1016/j.jseint.2021.11.007
17. RANIERI, R., LACOUTURE-SUAREZ, J. D., FERRERO, M., et al. Early rehabilitation vs. conventional immobilization in nonoperative treatment of proximal humeral fracture: A systematic review. European Review for Medical and Pharmacological Sciences. 2024, 28(11), 3771–3780. Dostupné online: https://doi.org/10.26355/eurrev_202406_36382
18. KWAN, L. L., MACINTYRE, N. J. Rehabilitation of proximal humerus fractures: An environmental scan of Canadian physiotherapy practice patterns. Journal of Novel Physiotherapy and Rehabilitation. 2017, 1, 104–119. Dostupné online: https://doi.org/10.29328/journal.jnpr.1001013
19. TILLE, E., LORENZ, F., BEYER, F., et al. Early functional improvements using continuous passive motion therapy after angular-stable plate osteosynthesis of proximal humerus fractures – Results of a prospective, randomized trial. Journal of Orthopaedic Surgery and Research. 2024, 19(1), 313. Dostupné online: https://doi.org/10.1186/s13018-024-04804-x
20. DURAN, E., DURMAZ, B., ATAMAZ, F. Ç., et al. Does interferential current provide additional benefit to orthopedic rehabilitation for the patients with proximal humeral fractures? A randomized controlled study. BMC Musculoskeletal Disorders. 2024, 25(1), 114. Dostupné online: https://doi.org/10.1186/s12891-024-07232-4
21. RICHARD, G. J., DENARD, P. J., KAAR, S. G., et al. Outcome measures reported for the management of proximal humeral fractures: A systematic review. Journal of Shoulder and Elbow Surgery. 2020, 29(10), 2175–2184. Dostupné online: https://doi.org/10.1016/j.jse.2020.04.006
22. NAH, M. F. K., PEREIRA, M. J., HEMAAVATHI, M., et al. Study on proximal humerus evaluation of effective treatment (SPHEER) – What is the effect of rehabilitation compliance on clinical outcomes of proximal humerus fractures. BMC Musculoskeletal Disorders. 2023, 24(1), 778. Dostupné online: https://doi.org/10.1186/s12891-023-06894-w
23. VOCHTELOO, A. J., KREKEL, P. R., VAN DE SANDE, M. A., et al. Range of motion implications of proximal humerus fractures: A case study. European Orthopaedics and Traumatology. 2011, 2(5–6), 153–156. Dostupné online: https://doi.org/10.1007/s12570-011-0080-8
24. BURCEA, C. C., BOBU, V., FERECHIDE, D., et al. New methodological aspects in rehabilitation after proximal humerus fracture. Balneo and PRM Research Journal. 2023, 14(2), 555.
25. ISMAEL, M. A. E.-F., LABIEB, M. M., KHALIL, S. S., et al. Effect of rehabilitation exercises on shoulder function after proximal humeral fracture surgery. Egyptian Journal of Health Care. 2023, 14(3), 537–548.
26. TONG, C. H., FANG, C. X. Rehabilitation progress following reverse total shoulder replacement and internal fixation for geriatric three- and four-part proximal humerus fractures – A propensity score matched comparison. BMC Musculoskeletal Disorders. 2023, 24, 566. Dostupné online: https://doi.org/10.1186/s12891-023-06669-3