ORIGINAL ARTICLE

ANNALS OF PUNJAB MEDICAL COLLEGE

OPEN ACCESS

# Treatment Outcomes of Neck of Femur Fracture (Garden Type IV) Treated with Cannulated Screws versus Cannulated Screws Plus Bone Graft

**Khair Ul Inam[1], Muhammad Ali[2], Mumraiz Salik Naqshband[3], Farhan Sarwar[4], Adeel Hameed[5], Zuhair Zubair[6]**

| | | Authors' Contribution |
|---|---|---|
| 1 | Medical Officer, DHQ Hospital, Alpurai Shangla Pakistan | *Statistical analysis, Data collection* |
| 2 | Assistant Professor, Department of Orthopedic Surgery Unit-2, King Edward Medical University / Mayo Hospital, Lahore Pakistan | *Abstract writing, Supervision* |
| 3 | Associate Professor, Department of Orthopedic Surgery Unit-2, King Edward Medical University / Mayo Hospital, Lahore Pakistan | *Methods writing* |
| 4 | Assistant Professor, Department of Orthopedic Surgery, University Medical & Dental College, Faisalabad Pakistan | *Introduction written* |
| 5 | Senior Registrar, Department of Orthopedic Surgery Unit-1, King Edward Medical University / Mayo Hospital, Lahore Pakistan | *Writing discussion and results* |
| 6 | Consultant Orthopedic Surgeon, 60 Bedded Government Hospital Khurrianwala, Faisalabad Pakistan | *References layout, Data interpretation* |

***Correspondence:*** *Dr. Khair Ul Inam*
*Medical Officer, DHQ Hospital, Alpurai Shangla Pakistan*
*Email: khairulinamorthopod@gmail.com*

Submitted for Publication: 16-05-2026
Revision Received: 15-06-2026
Accepted for Publication: 18-06-2026

## ABSTRACT

**Objective:** To compare the outcomes of completely displaced (Garden type IV) femoral neck fractures treated with and without bone grafting in addition to cannulated screws fixation. **Study Design:** Prospective observational study. **Settings:** Department of Orthopedic Surgery, Mayo Hospital, Lahore Pakistan. **Duration:** August 2023 to December 2024. **Methods:** This study involved 66 patients (33 in Group A treated with cannulated screws alone, and 33 in Group B treated with screws plus bone grafting). Bone union was assessed using the Radiologic Union Score for Hip fractures (RUSH), while functional outcome was evaluated using the Harris Hip Score. **Results:** Patients in Group B had significantly better outcomes than those in Group A, including union and functional outcomes. The mean Harris Hip Score for Group B was 88.86 ± 3.16, in comparison to 84.57 ± 4.46 for Group A ($p = 0.035$), showing improved functional status. Union was quicker in Group B, with a mean RUSH score for bridging of 9.89 ± 0.86, versus 8.63 ± 1.14 in Group A ($p = 0.019$). In addition, fracture line reduction was better in Group B, with a mean score of 9.83 ± 0.66 compared to 8.71 ± 0.95 in Group A ($p = 0.009$). **Conclusion:** In completely displaced femoral neck fractures, bone grafting in addition to cannulated screws fixation enhances radiological and functional outcomes compared to screws fixation alone. This also reduces complications such as nonunion and osteonecrosis.

***Keywords:*** *Femoral neck fracture, Cannulated screws, Bone graft, Harris Hip Score, RUSH score, Avascular necrosis.*

**How to Cite:** Inam KU, Ali M, Naqshband MS, Sarwar F, Hameed A, Zubair Z. Treatment Outcomes of Neck of Femur Fracture (Garden Type IV) Treated with Cannulated Screws versus Cannulated Screws Plus Bone Graft. APMC 2026;20(2):123-127. DOI: 10.29054/APMC/2026.1927



## INTRODUCTION

In orthopedic practice, femoral neck fractures are commonly encountered and may lead to significant morbidity and mortality. These intracapsular hip fractures commonly result in osteonecrosis of the femoral head and nonunion.[1] These fractures affect two groups: young, active people during intense activities, and older individuals with osteoporotic bones. These fractures result from high-energy trauma in younger patients and are often associated with multiple injuries and elevated rates of avascular necrosis and non-union. Outcomes depend on injury severity, degree of reduction, and the quality of fixation.[2] On the other hand, low-energy trauma is the mechanism of injury in elderly patients that occurs through direct factors like falls or external rotation, or indirect mechanisms when muscular forces exceed femoral neck strength. In the younger population, femoral neck fractures are mainly caused by high-impact trauma, like road traffic accidents or falls. Athletes and military individuals often have stress fractures, while those with osteoporosis experience insufficiency fractures.[3,4] Femoral neck fractures are becoming more frequent with the increasing age of the population. In the age bracket of 65-99, similar rates of femoral neck and intertrochanteric fractures have been reported. Hip fractures may be classified as either intracapsular or extracapsular. Intracapsular hip fractures account for 60 %, and about 80% of these fractures are displaced. Women and Caucasians are particularly at higher risk of sustaining such fractures.[5,6] In those with osteoporosis, neck of femur fractures usually result from trivial trauma, representing half of all hip fractures, with a higher frequency with increasing age.[7,8] On the contrary, in younger individuals, these fractures occur in just 3% of hip fractures, typically secondary to high-speed injuries.[9] The number of cases is expected to grow from 1.7 million in 1990 to 6.3 million by 2050.[10] In Pakistan, 46.3% of cases involve Garden type IV fractures.[11] These fractures are considered "unsolved" due to ongoing debates about treatment,

especially concerning whether to preserve or replace the femoral head in older patients. They are associated with complications like osteonecrosis and non-union. Treatment aims include early diagnosis, prompt surgery, anatomical reduction, capsule decompression, and stable internal fixation.[12] Treatment options include sliding hip screws, cannulated screws, total hip arthroplasty, and dynamic hip screws, which may include muscle-pedicle grafts and fibular grafts.[13] While hip replacement is advised for those at risk of osteonecrosis, younger patients need preservation techniques due to their higher functional demands.[14] Fibular bone grafts have yielded positive outcomes in cases of non-union and avascular necrosis, with the strut graft technique aiding in union and preventing head collapse.[15] For young adults with good bone quality, achieving anatomic reduction and stable internal fixation is crucial. There is an ongoing debate over the optimal fixation method to promote union and prevent femoral head osteonecrosis. Some experts advocate for using two or three cannulated screws, while others suggest dynamic hip screw fixation with an optional anti-rotational screw.[16] This study aims to evaluate the functional outcomes and radiological healing of Garden type IV femoral neck fractures treated with cannulated screws, both with and without bone grafts. The study's objectives are to compare these treatments in terms of functional results and radiological union.

## METHODS

This prospective observational study took place at the Department of Orthopedic Surgery, King Edward Medical University, Mayo Hospital, Lahore Pakistan from August 2023 to December 2024. Using the world Health Organization (WHO) sample size calculator 7.2b (hypothesis testing for a population mean, two-sided test), a sample of 66 patients (33 in each group) was estimated with a significance level of 5% and the power of test as 95% with expected functional outcome rates of 71.6% for the group treated solely with screws and 83.5% for the group treated with screws plus bone graft.[17] Approval was taken from the Institutional Review Board of the university through letter number 593/RC/KEMU dated 20/05/2023. A total of 66 patients, equally divided into two cohorts, were enrolled in the study, which used a non-probability, convenience sampling method. Patients of either gender, aged 18-60 years, presenting within a week of injury (based on history and clinical examination) and sustaining a closed femoral neck fracture (Garden type IV) were enrolled in the study. Patients having comorbidities like diabetes mellitus, chronic liver disease, chronic kidney disease, infection at the surgical site, a previous history of septic arthritis or avascular necrosis of the ipsilateral hip, previous surgeries around the affected joint, polytrauma, and fractures needing open reduction were excluded. Informed written consent was obtained from each patient or their representatives. Participants were divided into two groups, A and B, by lottery. All patients in Group A were treated with cancellous cannulated screws alone in an inverted triangle configuration, while Group B patients received bone grafting along with cannulated screws fixation.

**Surgical Technique:** All surgeries were conducted on a fracture table. Under sterile conditions, patients were positioned supine, and reduction was achieved using Whitman's technique, which involves applying traction to the hip in an abducted and externally rotated position, then internally rotating the hip. This was confirmed using an image intensifier, capturing antero-posterior and lateral views, in accordance with the Gardens alignment index, and the surgery was performed after satisfactory reduction. In Group A, after closed reduction, internal fixation was performed either percutaneously or through a small lateral incision, using three partially threaded (16 mm or 32mm), cannulated screws of 6.5mm diameter. At least one screw was placed along the calcar, and another along the posterior cortex. For Group B, the procedure involved using three partially threaded cannulated screws of the same specifications, along with a fibular bone graft. A surgical team carefully created a tunnel in the proximal femur to accommodate the fibular strut grafts, using a 10-mm cannulated reamer. At the same time, another team extracted the fibular graft from the same leg using the standard posterolateral method. After stabilizing the reduction with several 2-mm K wires, a channel for the fibular graft was made in the central or upper section of the head and neck. The fracture was then fixed with three 6.5-mm partially threaded cannulated screws, and the fibular graft was properly impacted. Patients were followed up in the outpatient department (OPD) at the 2nd, 6th, and 12th weeks post-surgery. Stitches were removed two weeks after the operation. Bone union was assessed using the RUSH criteria.[18] The functional outcome of the affected limb was evaluated with the Harris Hip score.[19] Complications such as implant failure, infection, and osteonecrosis were examined both clinically and radiologically. Data was organized, entered, and analysed using Statistical Package for the Social Sciences (SPSS) version 27.0. Continuous variables, such as age, RUSH union scores, and Harris hip score, were presented as mean ± standard deviation, while categorical variables, such as gender, were presented as frequencies and percentages. Variables of interest in both groups were compared using appropriate statistical tests, depending on variable type, distribution, and whether the data were parametric or nonparametric. A p-value of 0.05 or less was considered to be statistically significant.

## RESULTS

Out of the 66 participants, 29 (43.9%) were males, and 37 (56.1%) were females. The mean age of the patients was 43.36 ± 11.30 years. The average Harris Hip score was observed to be 86.71 ±4.40 while the average RUSH score for the "bridging" category was 9.26 ± 1.18, suggestive of satisfactory bone healing. Furthermore, the mean score for disappearance of the fracture line, another important indicator of bone healing, was 9.27 with a standard deviation of 0.99. (Table 1)

**Table 1: Characteristics of the participants**

| Variables | | Frequency (Percentage) |
|---|---|---|
| **Gender** | Male | 29 (43.9%) |
| | Female | 37 (56.1%) |
| | | **Mean ± S.D.** |
| **Age** | | 43.36 ± 11.30 |
| **Harris Hip Score** | | 86.71 ± 4.40 |
| **RUSH score** | Bridging | 9.26 ± 1.18 |
| | Disappearance of the fracture line | 9.27 ± 0.99 |

Of the 33 patients in group A, 14 (42.42%) were males, while 19 (57.58%) were females. The mean age of the patients was 43.80 years, with a standard deviation of 12.32 years. As a measure of functional outcome, the average Harris Hip score was 84.57 ± 4.46. For the radiological outcome, the Radiologic Union Score for Hip fractures (RUSH) score was utilized to assess bone healing. The mean bridging score, reflecting the formation of new bone between the fracture ends, was 8.63 ± 1.14. Moreover, the average score for disappearance of the fracture line was 8.71 with a standard deviation of 0.95, as depicted in Table 2.

**Table 2: Characteristics of group A participants**

| Variables | | Frequency (Percentage) |
|---|---|---|
| **Gender** | Male | 14 (42.42%) |
| | Female | 19 (57.58%) |
| | | **Mean ± S.D.** |
| **Age** | | 43.80 ± 12.32 |
| **Harris Hip Score** | | 84.57 ± 4.46 |
| **RUSH score** | Bridging | 8.63 ± 1.14 |
| | Disappearance of the fracture line | 8.71 ± 0.95 |

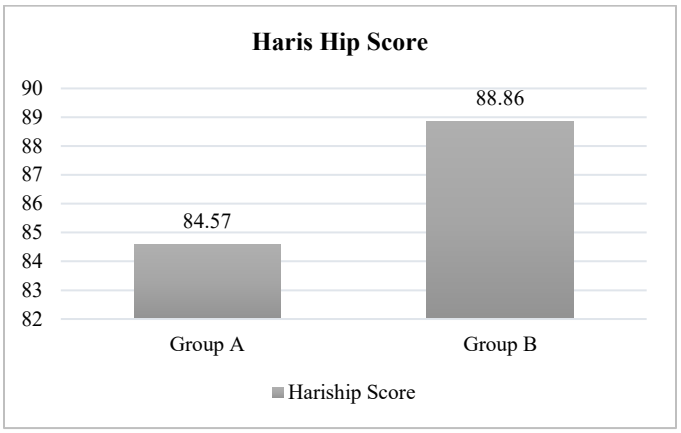
In a similar way, Group B comprised 33 individuals: 15 (45.45%) males and 18 (54.55%) females. The mean age of the participants was 42.91 ± 10.34 years. The observed mean Harris Hip score was 88.86 ± 3.16. To assess bone healing, the RUSH score was used as an evaluation tool, focusing on "bridging" and the "disappearance of the fracture line." For bridging, the mean score was 9.89, with a standard deviation of 0.86. Regarding the disappearance of the fracture line, the mean score was 9.83± 0.66. Table 3 illustrates group B findings.

**Table 3: Characteristics of group B**

| Variables | | Frequency (Percentage) |
|---|---|---|
| **Gender** | Male | 15 (45.45%) |
| | Female | 18 (54.55%) |
| | | **Mean ± S.D.** |
| **Age** | | 42.91 ± 10.34 |
| **Harris Hip Score** | | 88.86 ± 3.16 |
| **RUSH score** | Bridging | 9.89 ± 0.86 |
| | Disappearance of the fracture line | 9.83 ± 0.66 |

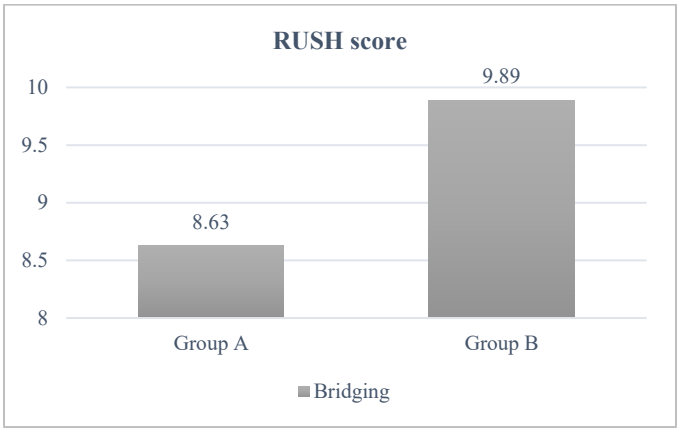
Comparing the observed findings of both groups, statistically significant differences were noted in both functional and radiological outcomes. Group B (screw fixation with bone grafting) showed markedly superior results across all the observed parameters than group A (screws fixation without bone grafting). The Harris Hip score, used to evaluate functional recovery, was significantly higher in Group B (88.86 ± 3.16) than in Group A (84.57 ± 4.46), with a p-value of 0.035, suggesting better functional outcomes in Group B, as depicted in Figure 1.

**Figure 1: Harris Hip score in group A and group B**



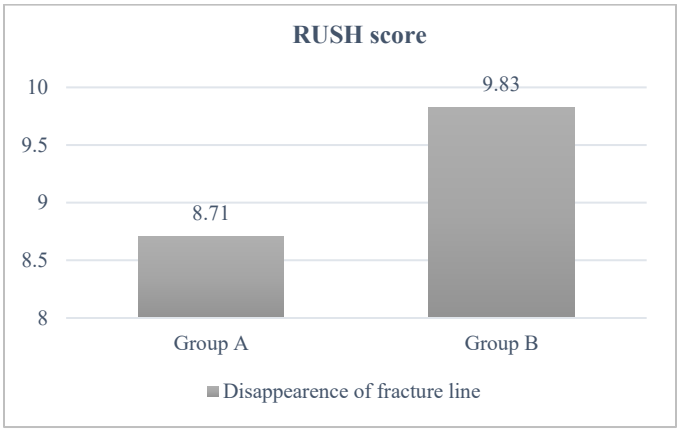

As far as the radiological outcome is concerned, the RUSH score, which evaluates bone bridging and formation of new bone, was significantly elevated in Group B (9.89 ± 0.86) than in Group A (8.63 ± 1.14), with a p-value of 0.019, indicating more effective bone healing (Figure 2).

**Figure 2: RUSH score (Bridging) in group A and group B**




In addition, the score for the disappearance of the fracture line, which is another parameter of bone healing, was also found to be significantly increased in Group B (9.83 ± 0.66) than in Group A (8.71 ± 0.95) (p = 0.009), as illustrated in Figure 3.

**Figure 3: RUSH score (Disappearance of fracture line) in group A and group B**



The functional and radiological comparisons between the groups are shown in Table 4.

**Table 4: Independent sample t-test for comparison of group A and group B**

| Variables | | Group A | Group B | *p*-Value |
|---|---|---|---|---|
| **Harris Hip Score** | | 84.57 ± 4.46 | 88.86 ± 3.16 | 0.035 |
| **RUSH score** | Bridging | 8.63 ± 1.14 | 9.89 ± 0.86 | 0.019 |
| | Disappearance of the fracture line | 8.71 ± 0.95 | 9.83 ± 0.66 | 0.009 |

## DISCUSSION

An increasing trend has been observed in the prevalence of femoral neck fractures among young adults and middle-aged individuals, particularly with high-energy injuries, such as road traffic accidents and falls.[20] The peculiar anatomy of the femoral neck is associated with an elevated risk of postoperative complications, specifically non-union and osteonecrosis of the femoral head. Conventionally, these fractures are fixed with three cannulated screws in an inverted triangular configuration. This method offers advantages such as minimal invasiveness, reduced intraoperative blood loss, shorter hospital stays, and shorter surgical time. However, for unstable and displaced Garden type IV fractures of the femoral neck, there is an elevated risk of postoperative complications and higher rates of mechanical failure after internal fixation. Augmentation of screw fixation with bone grafting is a feasible approach for treating displaced fractures of the femoral neck, as it can also reduce the risk of femoral head necrosis.[21]

This study was conducted at the department of orthopedic surgery of Mayo Hospital, affiliated to King Edward Medical University, Lahore, over a period of seventeen months to find out the effectiveness of bone grafting in addition to cannulated screws fixation in the management of completely displaced fractures of the femoral neck (Garden type IV). Overall, 66 patients were divided into two equal cohorts for the study. All patients in group A were managed with cannulated screws only, while participants in group B were treated with both bone grafts and cannulated screws fixation.

To assess clinical outcomes, the Harris Hip Score was used to evaluate bone healing. This score was developed to evaluate outcomes of hip surgery and is intended to assess different hip-related disabilities and treatment methods in adults. The scale has three parts. The first section contains questions about pain and its impact, which the patient answers. The following sections require a clinical assessment. As an indicator of dysfunction, an increased Harris Hip score suggests a better patient outcome. For radiological evaluation, the RUSH score was employed. This scoring system assesses bridging the fracture gap and the disappearance of the fracture line.

The study revealed no statistical differences in age, gender, or pain duration between the groups. The Harris Hip score was 88.86 ± 3.16 in group B (managed with cannulated screws and bone grafting), higher than 84.57 ± 4.46 in group A (treated with cannulated screws only), with a p-value of 0.035. An elevated score reflects superior functional outcomes with cannulated screws fixation combined with bone grafting as compared to cannulated screws fixation without bone grafting.

Radiological assessment of bone healing was performed by employing the RUSH score, taking into account bridging of edges at the fracture site and the fading of the fracture line. The Radiographic Union Score for Hip (RUSH) is a tool for evaluating fracture healing in the proximal femur (hip) using radiographs. It assesses bone healing, including callus formation, bridging of the cortices, and the visibility of fracture lines on plain X-rays. The RUSH score uses a standardized grading system to assess healing in various regions of the femur on X-rays. Each aspect is scored, and the cumulative score indicates the extent of bone union, with higher scores signifying better healing. In the group with cannulated screws and bone graft, the RUSH scores for bridging and fracture-line disappearance were 9.89 ± 0.86 and 9.83 ± 0.66, respectively. In contrast, the group with only cannulated screws had scores of 8.63 ± 1.14 and 8.71 ± 0.95, respectively. The p-value was 0.019 for bridging and 0.009 for the disappearance of the fracture line, indicating statistical significance. This result suggests that bone grafts achieved superior radiological healing compared to cannulated screws alone. Wei *et al*. reported that the Harris Hip score in the group with cannulated screws and fibular allograft was higher, at 80.8 ± 7.15 and 90.2 ± 2.86, compared to the ordinary cannulated screw group, which scored 79.3 ± 6.99 and 85.4 ± 5.49, with p-values of 0.195 and < 0.001 at follow-up periods of 1 year and 3 years, respectively.[22]

Moreover, patients in group B (combination of screw fixation and bone grafting) developed fewer post-operative complications, like osteonecrosis of the femoral head and non-union, as compared to group A with cannulated screws fixation only. Lou P *et al*. reported that using vascularized bone grafts with cannulated screws for femoral neck fractures resulted in excellent Harris Hip scores in 50% of patients and fair scores in 10%.[23] Lan Y *et al*. observed that deep circumflex iliac artery-bone grafting in combination with cannulated screws for treating femoral neck fracture resulted in a significantly increased mean Harris Hip score at 24 months after surgery as compared to the group without bone grafts (92.09 versus 84.98 with a p value of < 0.001).[24]

## CONCLUSION

This study showed that cannulated screws fixation in combination with bone grafting results in better outcomes than cannulated screws alone for Garden type IV femoral neck fractures. Patients with bone grafting showed better functional and radiological recovery. These patients had superior functional outcomes, indicating that bone grafts enhance structural integrity and recovery. The combined method of screw fixation and bone grafting significantly reduces complications such as nonunion and avascular necrosis of the femoral head, making it a preferable treatment option for high-risk patients.

## LIMITATIONS

The study's small sample size, the convenience sampling method, and the short follow-up period are the main limitations.

## SUGGESTIONS / RECOMMENDATIONS

Further research with larger sample sizes, longer follow-up periods, and multi-centered trials with proper randomization and blinding to evaluate long-term outcomes is recommended.

## CONFLICT OF INTEREST / DISCLOSURE

None.

## ACKNOWLEDGEMENTS

None.

## REFERENCES

1. Szymski D, Walter N, Lang S, Baertl S, Weber J, Alt V, et al. Incidence and Treatment of Intracapsular Femoral Neck Fractures in Germany. Arch Orthop Trauma Surg. 2023 May;143(5):2529-37.
2. Giustra F, Cacciola G, Pirato F, Bosco F, De Martino I, Sabatini L, et al. Indications, Complications, and Clinical Outcomes of Fixation and Acute Total Hip Arthroplasty for the Treatment of Acetabular Fractures: A Systematic Review. Eur J Orthop Surg Traumatol. 2024;34(1):47-57.
3. Shaw KA, Moreland CM, Hunt TJ, Barkley C, O'Brien F, Jackson KL. Femoral Neck Stress Fractures in Athletes and the Military. J Bone Joint Surg Am. 2022 Mar 2;104(5):473-82.
4. Campbell PG, Pope R, Simas V, Canetti EF, Schram B, Orr RM. Incidence and Risk Factors for the Development of Stress Fractures in Military Recruits and Qualified Personnel: A Systematic Review. Int J Environ Res Public Health. 2025 Nov;22(11):1760.
5. Bogoch E, Marcano-Fernández FA, Schemitsch EH, Zhou Q, Bzovsky S, Bhandari M, et al. High Rates of Imminent Subsequent Fracture After Femoral Neck Fracture in the Elderly. J Bone Joint Surg Am. 2022 Nov;104(22):1984-92.
6. Morin SN, Berger C, Papaioannou A, Cheung AM, Rahme E, Leslie WD, et al. Race/Ethnic Differences in the Prevalence of Osteoporosis, Falls and Fractures: A Cross-Sectional Analysis of the Canadian Longitudinal Study on Aging. Osteoporos Int. 2022 Dec;33(12):2637-48.
7. Reddy BA, Sreenath M, Macherla VG, Vakati S, Gorla VK. Epidemiological Trends and Risk Factors of Hip Fractures in Elderly Patients: A Retrospective Study. Eur J Cardiovasc Med. 2025 Oct;15(10):200-5.
8. Almeida PP, Bonfim DC. Trends in Fracture-Related Hospitalizations and Mortality in Brazil, 2015-2024. Epidemiologia (Basel). 2026 May 4;7(3):63-9.
9. Varieur BM, White RC, Schmitt DR, Brown NM. Who Breaks Their Hip? A Decade of Traumatic Hip Fracture Data. J Orthop. 2025;62(2):7-12.
10. Hawley S, Dela S, Burton A, Paruk F, Cassim B, Gregson CL. Incidence and Number of Fragility Fractures of the Hip in South Africa: Estimated Projections From 2020 to 2050. Osteoporos Int. 2022 Dec;33(12):2575-83.
11. Shaikh SA, Hussain S, MQ AS, Ahmed N, Jamali AR. Osteosynthesis of Fractures Neck Femur With Cannulated Screws: Evaluation of Risk Factors for Postoperative Complications. J Pak Med Assoc. 2021 Aug;71(8):S59-63.
12. Davidson A, Blum S, Harats E, Kachko E, Essa A, Efraty R, et al. Neck of Femur Fractures Treated With the Femoral Neck System: Outcomes of One Hundred and Two Patients and Literature Review. Int Orthop. 2022 Sep;46(9):2105-15.
13. Zelle BA, Salazar LM, Howard SL, Parikh K, Pape HC. Surgical Treatment Options for Femoral Neck Fractures in the Elderly. Int Orthop. 2022 May;46(5):1111-22.
14. Collinge CA, Finlay A, Rodriguez-Buitrago A, Beltran MJ, Mitchell PM, Mir HR, et al. Treatment Failure in Femoral Neck Fractures in Adults Less Than 50 Years of Age: Analysis of 492 Patients Repaired at 26 North American Trauma Centers. J Orthop Trauma. 2022 Jun;36(6):271-9.
15. Mehraj M, Khurana S, Kumar B, Chahal JS, Joshi UR, Jain A, et al. Fixation of Fresh Femoral Neck Fractures Using Fibular Strut Graft Along With Cannulated Screws. Ortop Traumatol Rehabil. 2022;24(5):319-23.
16. Sun X, Han Z, Cao D, Han C, Xie M, Zeng X, et al. Finite Element Analysis of Six Internal Fixations in the Treatment of Pauwels Type III Femoral Neck Fracture. Orthop Surg. 2024 Jul;16(7):1695-709.
17. Wei Y, Lin T, Liu Y, Chen Z, Zhou C. Fibula Allograft With Cannulated Screw Fixation Versus Ordinary Cannulated Screw Fixation for Femoral Neck Fractures: A 10-Year Retrospective Comparative Study. J Orthop Surg Res. 2023;18(1):570-8.
18. Zhou TJ, Jiang S, Ren JK, Zhang X, Liu WX, Yan P, et al. Improving Agreement in Assessing Subtrochanteric Fracture Healing Among Orthopedic Surgeons Using the Radiographic Union Score for Hip (RUSH). BMC Musculoskelet Disord. 2024;25(1):798.
19. Alshammari AO, Alsofyani MA, Alhammad AS, Alharbi MS, Alshehri SH, Alharbi MS, et al. Reliability of the Harris Hip Score Among Observers in the Management of Femoral Neck Fracture. Asian J Pharm Res Health Care. 2025;17(3):306-11.
20. Xu B, Radojčić MR, Anderson DB, Shi B, Yao L, Chen Y, et al. Trends in Prevalence of Fractures Among Adults in the United States, 1999-2020: A Population-Based Study. Int J Surg. 2024 Feb;110(2):721-32.
21. Yixuan H, Xinwei Y, Feifei G, Jianbin M, Mingbin G, Hongzhong X, et al. Effect of Sclerosis Bands in Femoral Head Necrosis on Non-Vascularized Fibular Grafting—A Finite Element Study. Orthop Surg. 2024 Oct;16(10):2526-38.
22. Lou P, Zhou G, Wei B, Deng X, Hou D. Bone Grafting for Femoral Head Necrosis in the Past Decade: A Systematic Review and Network Meta-Analysis. Int J Surg. 2023 Mar;109(3):412-8.
23. Lan Y, Sun T. Efficacy of Internal Fixation Alone Versus Combined Pedicled Bone Grafting in Young People With Fresh Garden Type III/IV Femoral Neck Fracture: A Systematic Review and Meta-Analysis. Eur J Orthop Surg Traumatol. 2025;35(1):197-204.