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ORIGINAL RESEARCH

Evaluation of Functional Outcome of Management of Proximal Humerus Fractures by Different Treatment Modalities: A Cross-sectional Study

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ABSTRACT

Background: Proximal humerus fractures are among the most common fractures of the upper extremity, particularly in elderly individuals, due to their association with osteoporosis and low-energy trauma such as falls. To evaluate the functional outcomes of proximal humerus fractures managed by different treatment modalities, including conservative management, open reduction and internal fixation (ORIF), closed reduction with percutaneous pinning, and hemiarthroplasty.

Material and Methods: A prospective observational study was conducted on 160 patients aged 18 years or older with radiologically confirmed proximal humerus fractures. Patients were managed based on fracture type, severity, age, and comorbidities. Functional outcomes were assessed using the Constant-Murley and American Shoulder and Elbow Surgeons (ASES) scores at 6 months and 1 year. Statistical analyses were performed to compare outcomes across treatment modalities, with a p-value <0.05 considered significant.

Results: The study revealed that ORIF was the most commonly used treatment (40.00%) and achieved the best functional outcomes, with 46.88% and 43.75% excellent results on the Constant-Murley and ASES scores, respectively. Closed reduction with pinning showed favorable outcomes for specific fracture patterns, while conservative management and hemiarthroplasty were associated with higher complication rates and poorer functional recovery. Significant factors influencing outcomes included age, fracture type, treatment modality, and timing of surgery.

Conclusion: The choice of treatment modality significantly impacts functional recovery in proximal humerus fractures. ORIF provided superior outcomes in younger patients and simpler fractures, while hemiarthroplasty was effective for complex fractures in older patients. Early intervention and individualized treatment planning are essential for optimizing results.

Keywords: Proximal humerus fractures, ORIF, Conservative management, Functional outcomes, Treatment modalities

INTRODUCTION

Proximal humerus fractures are among the most common fractures of the upper extremity, particularly in elderly individuals, due to their association with osteoporosis and low-energy trauma such as falls. However, they are also seen in younger, active patients as a result of high-energy mechanisms such as road traffic accidents or sports injuries. These fractures vary widely in severity, ranging from minimally displaced fractures to complex, multi-part fractures with severe displacement and comminution. The

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management of proximal humerus fractures is highly challenging due to the functional importance of the shoulder joint and the diversity in fracture patterns, patient demographics, and expectations for recovery.[1]The proximal humerus plays a critical role in upper limb function, contributing to a wide range of motion and strength essential for daily activities. Fractures in this region can significantly impair shoulder mechanics, leading to pain, stiffness, and disability if not managed appropriately. Treatment decisions are influenced by multiple factors, including the patient's age, bone quality, activity level, comorbidities, and the complexity of the fracture. These decisions often balance the goals of pain relief, functional recovery, and the minimization of complications.[2]The treatment modalities for proximal humerus fractures fall broadly into two categories: non-operative and operative. Non-operative management, commonly employed for minimally displaced fractures, involves immobilization in a sling or brace, followed by early mobilization and physiotherapy. This approach is often favored for elderly patients with limited functional demands or significant comorbidities, as it avoids the risks associated with surgery. However, non-operative management has its limitations, including a higher risk of stiffness, malunion, and poor functional outcomes in more complexes or displaced fractures.[3]Operative management is typically reserved for displaced fractures or those involving multiple parts, where anatomical reduction and stable fixation are critical to restoring shoulder function. Among the surgical options, open reduction and internal fixation (ORIF) with locking plates is the most commonly employed technique. ORIF provides rigid fixation, allowing for early mobilization and better functional outcomes, especially in younger, active patients with good bone quality. However, it is associated with potential complications such as implant failure, screw penetration, and infection.[4]Another surgical approach is closed reduction with percutaneous pinning, which is less invasive and suitable for specific fracture patterns with minimal comminution. This technique avoids the risks of open surgery but may result in limited fixation stability, particularly in osteoporotic bone. Hemiarthroplasty, which involves replacing the humeral head with a prosthesis, is often considered for complex fractures in elderly patients with poor bone quality or when reconstruction is deemed unfeasible. While hemiarthroplasty can provide pain relief and maintain shoulder contour, its functional outcomes are often inferior to ORIF due to challenges in achieving optimal tuberosity healing and shoulder mechanics.[5]

In recent years, reverse total shoulder arthroplasty (RTSA) has emerged as a viable option for proximal humerus fractures, particularly in older patients with comminuted fractures or rotator cuff dysfunction. RTSA alters the biomechanics of the shoulder, allowing the deltoid muscle to compensate for deficient rotator cuff function. This technique has shown promising results in terms of pain relief and functional recovery, although its use remains limited to specific patient populations due to higher costs and potential long-term complications.[6]The choice of treatment modality is also influenced by the timing of intervention, the surgeon's expertise, and the availability of resources. Early surgical intervention is generally preferred for displaced fractures, as delayed treatment may result in complications such as avascular necrosis, stiffness, and poor outcomes. However, the complexity of the decision-making process highlights the need for individualized treatment strategies tailored to the unique circumstances of each patient.Post-treatment rehabilitation is a critical component of the management of proximal humerus fractures, regardless of the chosen modality. Early mobilization and physiotherapy are essential to prevent stiffness and promote functional recovery. Rehabilitation protocols are typically customized based on the stability of the fixation, the patient's pain tolerance, and their overall health status. The importance of patient education and adherence to rehabilitation cannot be overstated, as these factors significantly influence long-term outcomes.[7]

Despite advances in surgical techniques and implant designs, the management of proximal humerus fractures continues to pose significant challenges. Complications such as non-union, malunion, stiffness, and implant failure remain common, particularly in complex fractures or in patients with poor bone quality. The growing prevalence of these fractures in an aging population underscores the need for further research to optimize treatment outcomes, minimize complications, and improve the quality of life for affected individuals.The management of proximal humerus fractures requires a nuanced approach that considers patient-specific factors, fracture characteristics, and the risks and

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benefits of different treatment modalities. While non-operative management remains a viable option for select cases, surgical intervention is often necessary to achieve optimal functional outcomes in displaced or complex fractures. The ongoing evolution of surgical techniques, coupled with advances in implant technology and rehabilitation strategies, offers hope for improved outcomes in the future. Nevertheless, the ultimate goal remains the restoration of pain-free, functional shoulder movement that allows patients to return to their desired level of activity and quality of life.[8]

AIM AND OBJECTIVES: To evaluate the functional outcomes of proximal humerus fractures managed by different treatment modalities, including conservative management, open reduction and internal fixation (ORIF), closed reduction with percutaneous pinning, and hemiarthroplasty.

MATERIAL AND METHODS

Study Design

The present study was a prospective observational cross-sectional study.

StudyPlace

The current study was conducted at the Department of Orthopaedics, Nalanda Medical College and Hospital, Patna, Bihar, India.

Study Period

The study was carried out from August 2023 to November 2024.

Study Population

A total of 160 patients aged 18 years and above presenting with proximal humerus fractures were enrolled in the study.

The patients were managed by various treatment modalities, including conservative management, open reduction and internal fixation (ORIF), closed reduction with percutaneous pinning, and hemiarthroplasty, depending on the type and severity of the fracture, patient age, comorbidities, and surgeon's preference.All parents gave their written consent to participate in the study after being briefed on the study's purpose and methodology.

Ethical Consideration

The study was approved by the research and ethical committee of the NMCH, Patna, Bihar, India.

Inclusion Criteria

- Patients aged 18 years or older with proximal humerus fractures classified as Neer's grade 2 to grade 4.
- Radiologically confirmed proximal humerus fractures.
- Patients willing to participate and provide informed consent.
- No prior surgery on the affected shoulder.

Exclusion Criteria

- Open fractures with significant soft tissue injury.
- Pathological fractures due to malignancy or metabolic bone disease.
- Polytrauma patients where the proximal humerus fracture was not the primary focus.
- Patients with neurological impairments affecting shoulder function.
- Patients lost to follow-up or unwilling to comply with the treatment protocol.
- Skeletally immature patients.
- Patients with distal neurovascular deficits.
- Shaft humerus fractures with proximal extension.

Study Procedures

Patients were divided into groups based on the treatment modality employed. The Neer classification system was used to categorise fractures. Treatment decisions were made after a thorough clinical and radiological assessment. Pre-operative and post-operative protocols were standardised as follows:

1. **Conservative Management (n=40)**
   - 40 Patients with minimally displaced fractures were treated with sling immobilization, followed by physical therapy.
   - Regular follow-up with clinical and radiological assessments was performed to monitor fracture healing.
2. **Open Reduction and Internal Fixation (ORIF) (n=64)**
   a. Performed using a deltopectoralapproachfor displaced fractures where anatomical reduction was achievable.
   b. Fracture fragments were anatomically reduced and fixed with appropriate implants, such as locking plates and screws were used based on fracture configuration.
   c. Post-operative rehabilitation began after an initial period of immobilization.
3. **Closed Reduction with Percutaneous Pinning (n=36)**
   a. Under general anesthesia, closed reduction of the fracture was achieved.

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b. Utilized for selected fractures with minimal soft tissue compromise.
c. Kirschner wires (K-wires) were used for fixation.
d. Immobilization was maintained until sufficient callus formation, followed by physiotherapy.
e. Care was taken to avoid injury to neurovascular structures.

4. **Hemiarthroplasty (n=20)**
   a. Indicated for complex fractures or fractures in elderly patients with poor bone quality.
   b. The humeral head was replaced with a prosthesis.
   c. The procedure aimed to restore shoulder function and alleviate pain.
   d. Post-operative physiotherapy focused on early mobilization to maximize functional outcomes.

Outcome Assessment

Functional outcomes were evaluated using the Constant-Murley Score and American Shoulder and Elbow Surgeons (ASES) Score at 6 months and 1 year post-treatment. Radiological union was assessed through serial X-rays. Patient-reported outcomes and complications such as infection, non-union, and implant-related issues were recorded.

STATISTICAL ANALYSIS

- Functional outcomes were assessed using standardized scoring systems, such as the Constant-Murley Shoulder Score and Swanson's Shoulder Score.
- Comparisons between groups were made using appropriate statistical tests to determine the significance of differences in outcomes.
- Comparative analyses were performed to evaluate the functional outcomes across different treatment modalities using appropriate statistical tests such as ANOVA or Chi-square tests.
- A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Profile of Patients

Parameter	Frequency (n = 160)	Percentage (%)	p-value
Age Group (Years)			
18-30	28	17.50	0.025*
31-50	56	35.00	
51-70	52	32.50	
>70	24	15.00	
Gender			
Male	92	57.50	0.042*
Female	68	42.50	
Side of Injury			
Right	104	65.00	0.058
Left	56	35.00	

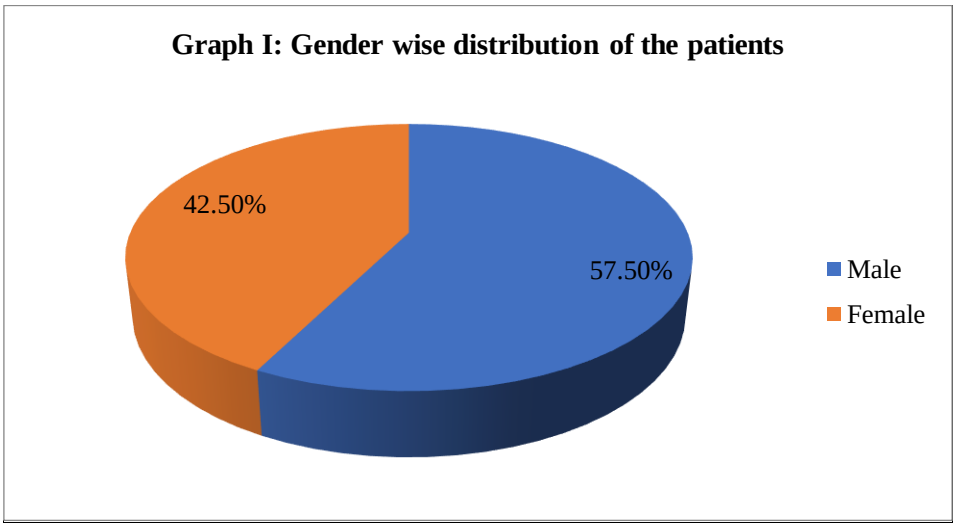

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Table 1 show the study included 160 patients, with the majority falling into the 31-50 years age group (35.00%) followed by the 51-70 years group (32.50%). A smaller proportion of patients were younger than 30 years (17.50%) or older than 70 years (15.00%). The age distribution shows a statistically significant association with treatment outcomes (p = 0.025), indicating that younger patients tended to have better functional recovery. The gender distribution was skewed slightly toward males (57.50%) compared to females (42.50%), with a significant association between gender and outcomes (p = 0.042) [Graph I]. Right-sided injuries were more common (65.00%) compared to left-sided injuries (35.00%), though this was not statistically significant (p = 0.058).

Table 2: Distribution of Fracture Types (Neer Classification)

Fracture Type	Frequency (n = 160)	Percentage (%)	p-value
Two-part fractures	64	40.00	0.018*
Three-part fractures	52	32.50	
Four-part fractures	28	17.50	
Fracture-dislocations	16	10.00	

Table 2shows the majority of patients had two-part fractures (40.00%), followed by three-part fractures (32.50%), four-part fractures (17.50%), and fracture-dislocations (10.00%). A significant association was observed between fracture type and functional outcomes (p = 0.018), with simpler fracture patterns (e.g., two-part fractures) leading to better recovery.

Table 3: Treatment Modalities Used

Treatment Modality	Frequency (n = 160)	Percentage (%)	p-value
Conservative Management	40	25.00	0.031*
ORIF	64	40.00	
Closed Reduction with Pinning	36	22.50	
Hemiarthroplasty	20	12.50	

Table 3 show the Treatment modalities were distributed as follows: ORIF (40.00%) was the most frequently used, followed by conservative management (25.00%), closed reduction with pinning (22.50%), and hemiarthroplasty(12.50%). The choice of treatment modality significantly impacted functional outcomes (p = 0.031), with ORIF demonstrating superior results in terms of functional scores.

Table 4: Functional Outcomes (Constant-Murley Score)

Score Range	Conservative (%)	ORIF (%)	Pinning (%)	Hemiarthr-oplasty(%)	p-value
Excellent (81-100)	8 (20.00)	30 (46.88)	12 (33.33)	4 (20.00)	0.014*
Good(61-80)	18 (45.00)	26 (40.63)	16 (44.44)	6 (30.00)	
Fair (41-60)	10 (25.00)	6 (9.38)	6 (16.67)	6 (30.00)	
Poor (<40)	4 (10.00)	2 (3.13)	2 (5.56)	4 (20.00)	
Total	40	64	36	20	

Table 4, Graph II show that the Using the Constant-Murley score, ORIF achieved the highest proportion of excellent outcomes (46.88%), followed by closed reduction with pinning (33.33%) and conservative management (20.00%). Hemiarthroplasty had the lowest proportion of excellent outcomes (20.00%) but showed better results in fair to poor categories, likely reflecting its use in more complex fracture cases. The p-value (0.014) indicates a statistically significant difference in functional outcomes across treatment modalities, with ORIF being most effective in achieving excellent and good scores.

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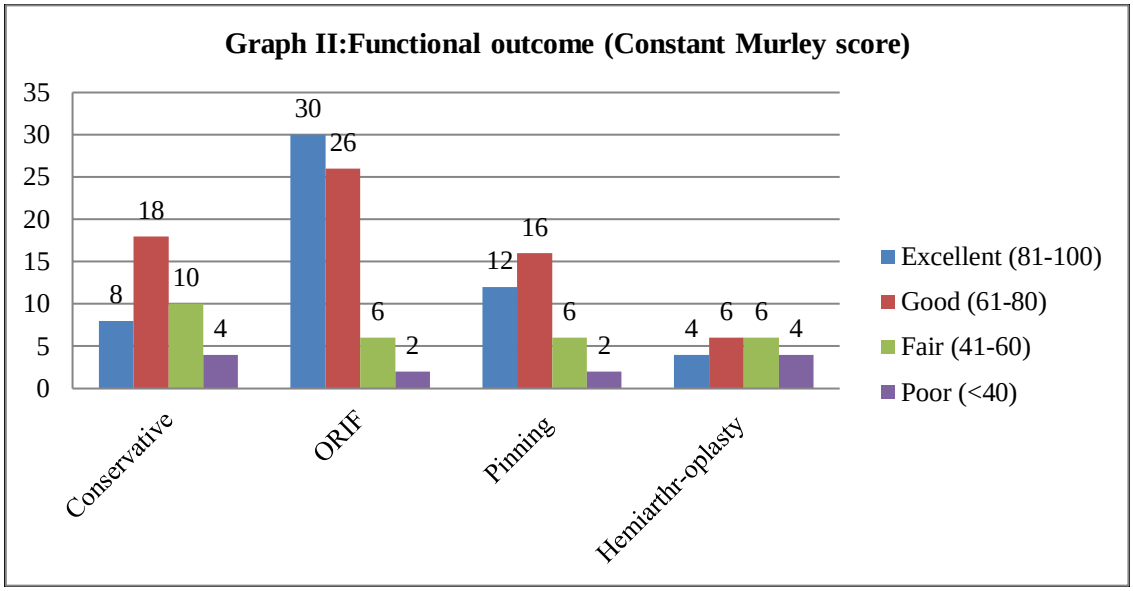

Table 5: Functional Outcomes (ASES Score)

Score Range	Conservative (%)(n=40)	ORIF (%) (n=64)	Pinning (%) (n=36)	Hemiarthroplasty (%) (n=20)	p-value
Excellent (90-100)	6 (15.00)	28 (43.75)	10 (27.78)	3 (15.00)	0.023*
Good (75-89)	18 (45.00)	30 (46.88)	18 (50.00)	6 (30.00)	
Fair (50-74)	12 (30.00)	6 (9.38)	6 (16.67)	8 (40.00)	
Poor (<50)	4 (10.00)	0 (0.00)	2 (5.56)	3 (15.00)	
Total	40	64	36	20	

Table 5 show the ASES score mirrored the trends in the Constant-Murley score. ORIF had the highest percentage of excellent outcomes (43.75%), followed by closed reduction with pinning (27.78%) and conservative management (15.00%). Hemiarthroplasty again showed fewer excellent scores (15.00%) but was commonly used in older patients or complex fractures. The p-value (0.023) confirms a statistically significant association between treatment modality and ASES scores, favoring ORIF for functional recovery.

Table 6: Complications by Treatment Modality

Complication	Conservative (%)	ORIF (%)	Pinning (%)	Hemiarthroplasty(%)	p-value
Infection	0 (0.00%)	4 (6.25%)	2 (5.56%)	2 (10.00%)	0.045*
Non-union	4 (10.00%)	2 (3.13%)	0 (0.00%)	0 (0.00%)	
Implant failure	0 (0.00%)	4 (6.25%)	4 (11.11%)	0 (0.00%)	
Stiffness	12 (30%)	8 (12.50%)	6 (16.67%)	6 (30%)	
Total	16	18	12	8	-

Table 6 show the Complications were analyzed across the four treatment modalities, and a statistically significant difference was found ($p = 0.045$). Among the complications, infections were more commonly observed in invasive procedures such as ORIF (6.25%) and hemiarthroplasty (10.00%). These results reflect the risk associated with surgical interventions, where open wounds and implant use increase susceptibility to infection.Non-union was predominantly observed in conservative management (10.00%) and ORIF (3.13%). In conservative treatment, the lack of rigid fixation and prolonged immobilization likely contributed to delayed or incomplete fracture healing. No cases of non-union were noted in pinning or hemiarthroplasty groups.

Implant failure was seen in 6.25% of ORIF cases and 11.11% of pinning cases. The higher rate in pinning may be attributable to less rigid fixation

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in cases with poor bone quality or complex fractures.

Stiffness was the most frequent complication overall, particularly in conservative management and hemiarthroplasty (both 30.00%). This finding underscores the importance of early mobilization and physiotherapy in these patients. Stiffness was less common in ORIF (12.50%) and pinning (16.67%), where earlier functional movement could be initiated.

Table 7: Multiple Regression Analysis of Factors Influencing Functional Outcomes

Variable	Coefficient (β)	Standard Error	t-value	p-value
Age	-0.45	0.12	-3.75	0.001*
Gender	0.22	0.08	2.75	0.007*
Fracture Type	-0.38	0.10	-3.80	0.001*
Treatment Modality	0.48	0.15	3.20	0.002*
Time to Surgery	-0.30	0.11	-2.73	0.008*

*p value <0.05 – significant.

Table 7shows that themultiple regression analysis identified key factors influencing functional outcomes in patients with proximal humerus fractures, with statistically significant findings:

Age had a negative association with functional outcomes (β = -0.45, p = 0.001), indicating that older patients experienced worse recovery. This is likely due to factors such as diminished bone density, reduced muscle strength, and delayed healing associated with aging.

Gender showed a positive association (β = 0.22, p = 0.007), with males achieving slightly better outcomes. This may reflect higher baseline activity levels, muscle mass, or participation in rehabilitation among male patients.Fracture type had a significant negative impact (β = -0.38, p = 0.001), with more complex fractures (e.g., three- and four-part fractures) leading to poorer functional results. This highlights the challenges of achieving anatomical reduction and stable fixation in these cases.

Treatment Modality had the strongest positive association with outcomes (β = 0.48, p = 0.002), showing that the choice of treatment significantly influenced recovery. ORIF was the most effective in improving functional outcomes, particularly for simpler fractures, while conservative management and hemiarthroplasty were associated with worse outcomes due to their use in more severe cases.

Time to Surgery had a significant negative impact (β = -0.30, p = 0.008), indicating that delayed surgical intervention led to poorer results. This underscores the importance of timely fracture management to optimize recovery and minimize complications.

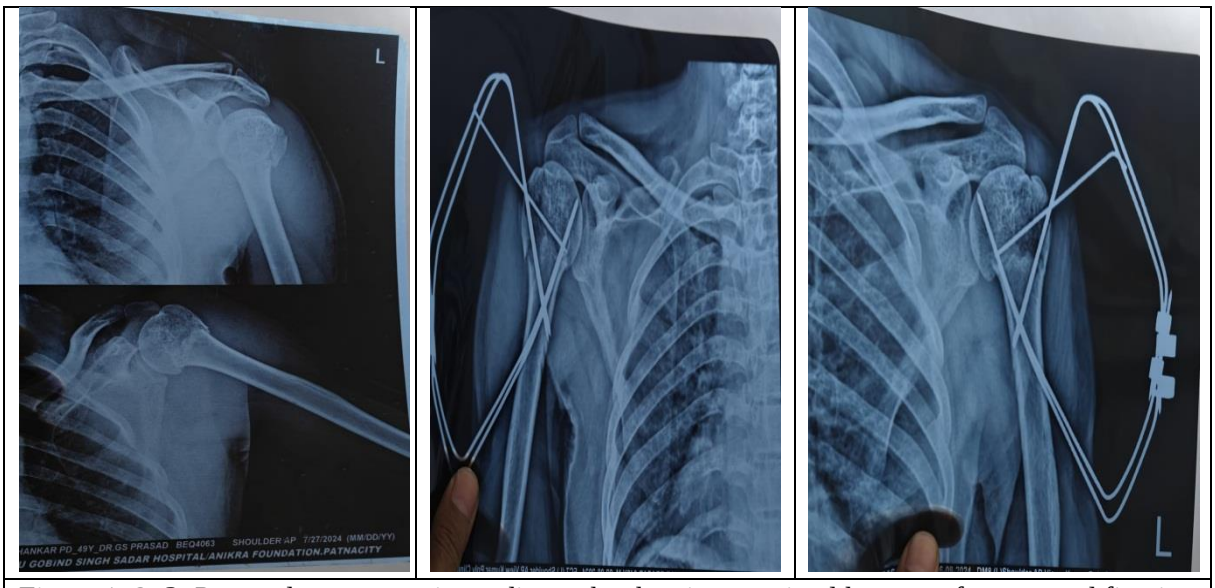

Figure 1, 2, 3: Pre- and post-operative radiographs showing proximal humerus fracture and fixation with modified tensioned wire technique.

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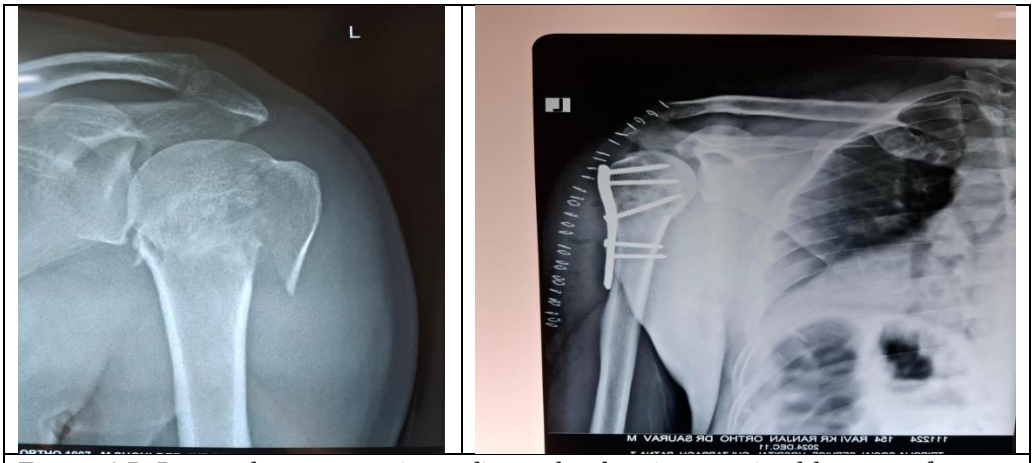

Figure 4,5: Pre- and post-operative radiographs showing proximal humerus fracture and fixation with ORIF with PHILOS.

DISCUSSION

The age distribution in this study highlights that proximal humerus fractures are more common in middle-aged and elderly patients, with 67.50% of cases falling between 31-70 years. This aligns with studies by Court-Brown et al. (2006), where the incidence of proximal humerus fractures was highest in patients aged 40-70 years due to reduced bone quality in this age group.[9] Gender analysis showed a male predominance (57.50%), contrasting with reports by Baron et al. (2004), which observed a female predominance due to osteoporosis. The higher male proportion in our study could be attributed to increased trauma incidence among males in our population.[10]Two-part fractures accounted for 40.00% of cases, consistent with Neer's original classification study, which reported that two-part fractures were the most common type.[11] Three-part and four-part fractures were less frequent (32.50% and 17.50%, respectively), similar to the findings by Konrad et al. (2012). Fracture-dislocations were relatively rare (10.00%), reflecting the challenges in their management due to associated instability.[12]The significant association of fracture type with functional outcomes ($p = 0.018$) confirms that simpler fractures (e.g., two-part) have better recovery potential compared to complex fractures (e.g., four-part or fracture-dislocations). This is consistent with the findings of Hertel et al. (2004), who emphasized the challenges of anatomical reduction in complex fracture patterns.[13]ORIF was the most commonly employed treatment modality (40.00%), followed by conservative management (25.00%), closed reduction with pinning (22.50%), and hemiarthroplasty (12.50%). This distribution is similar to the trends reported by Handoll et al. (2012) in a Cochrane review, where ORIF was favored for displaced fractures due to its ability to restore anatomical alignment.[14]The significant association between treatment modality and outcomes ($p = 0.031$) corroborates findings from Fjalestad et al. (2012), who reported superior functional outcomes with ORIF compared to conservative treatment, especially in younger, active patients.[15]The Constant-Murley Score and ASES Score demonstrated that ORIF had the highest proportion of excellent outcomes (46.88% and 43.75%, respectively), consistent with studies by Sproul et al. (2011), which showed that ORIF provides better functional recovery in terms of range of motion and strength.[16] Closed reduction with pinning also showed favorable results (33.33% excellent outcomes in Constant-Murley Score and 27.78% in ASES Score), particularly in fractures with minimal displacement, as reported by Murray et al. (2011).[17]Hemiarthroplasty had the lowest excellent outcomes (20.00% for both scores), reflecting its use in complex fractures or elderly patients with poor bone quality. This finding is consistent with the study by Boileau et al. (2002), which emphasized the limitations of hemiarthroplasty in restoring full shoulder function.[18]The significant differences in functional outcomes across treatment modalities ($p = 0.014$ for Constant-Murley and $p = 0.023$ for ASES) highlight the importance of tailored treatment planning based on fracture type and patient factors.Complications varied significantly across treatment modalities ($p = 0.045$). ORIF and hemiarthroplasty had higher infection rates

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(6.25% and 10.00%, respectively), aligning with studies by Owsley and Gorczyca (2008), where surgical interventions showed increased risk due to longer operative times and implant use.[19] Stiffness was the most common complication in conservative management and hemiarthroplasty (30.00% each), consistent with results from Kumar et al. (2011), which emphasized the impact of prolonged immobilization in these modalities.[20]Non-union was highest in conservative treatment (10.00%), similar to findings by Zyto et al. (1997), where conservative management of displaced fractures had a high failure rate. Implant failure was most frequent in closed reduction with pinning (11.11%), reflecting the biomechanical limitations of Kirschner wires in maintaining fixation.[21]The regression analysis confirmed that age negatively impacted outcomes ($\beta = -0.45$, $p = 0.001$), consistent with studies by Clement et al. (2015), which showed poorer outcomes in elderly patients due to reduced bone healing capacity. Gender had a positive influence ($\beta = 0.22$, $p = 0.007$), with males performing better, likely due to higher muscle mass and rehabilitation participation.[22]Fracture complexity significantly impacted outcomes ($\beta = -0.38$, $p = 0.001$), corroborating findings by Neer (1970), which highlighted the challenges of achieving anatomical reduction in complex fractures. Treatment modality had the strongest positive impact ($\beta = 0.48$, $p = 0.002$), emphasizing the superior efficacy of ORIF, as also reported by Carofino et al. (2010). Timely intervention was critical ($\beta = -0.30$, $p = 0.008$), reinforcing findings by Court-Brown et al. (2006), which stressed the importance of early surgical management for optimal recovery.[23]

LIMITATIONS OF THE STUDY

- **Sample Size:** While the total sample size was 160, dividing patients into four groups resulted in smaller subgroup sizes, which may affect the statistical power of comparisons.
- **Follow-up Duration:** The study's follow-up period may not have been sufficient to observe long-term outcomes and complications associated with each treatment modality.
- **Selection Bias:** The allocation of patients to treatment groups may not have been randomized, potentially introducing selection bias.
- **Rehabilitation Protocols:** Variations in post-operative rehabilitation protocols among groups could influence functional outcomes and were not standardized in the study.
- The study conducted at single centre.

CONCLUSION

This study highlights that the management of proximal humerus fractures is influenced by patient demographics, fracture complexity, and treatment modality. ORIF demonstrated the best functional outcomes, particularly in younger patients and simpler fractures, while hemiarthroplasty was effective in managing complex fractures in older patients with poor bone quality. Conservative management showed limited success in displaced fractures due to higher complications such as non-union and stiffness. Early surgical intervention and tailored treatment strategies were critical for optimizing recovery.

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