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Comparative Analysis of Proximal Humerus Fracture Outcomes with PHILOS Plating Alone and with Autologous Fibular Bone Graft

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Abstract:

Proximal humeral fractures (PHFs) are prevalent in older populations due to osteoporosis, often requiring surgical intervention in complex cases. Traditional management with the Proximal Humeral Internal Locking System (PHILOS) plate has shown effectiveness; however, it may fall short in severe cases where additional support is needed. This study compares outcomes of PHILOS plating alone versus PHILOS plating augmented with autologous non-vascularized fibular bone graft. The primary aim was to assess and compare functional outcomes, fracture union, and complication rates between these two treatment groups. This prospective study included patients diagnosed with PHFs, classified under Neer's system, and treated either with PHILOS plating alone (Group A) or with PHILOS plating augmented by fibular grafting (Group B). Both groups underwent Open Reduction Internal Fixation using a deltopectoral approach. Postoperative assessments were performed at 15 days, 6 weeks, 3 months, and 6 months, measuring parameters like Visual Analogue Scale (VAS) scores, Activities of Daily Living (ADL), and range of motion. Patients treated with fibular grafting showed superior long-term functional recovery, particularly in complex fractures. Though early postoperative morbidity was higher in Group B, functional outcomes improved significantly over time compared to Group A. The augmented approach also demonstrated improved fracture stability and alignment, reducing fixation failure rates. This study suggests that fibular bone grafting with PHILOS plating may offer better outcomes in terms of pain relief, structural stability, and functional improvement for severe PHFs. However, further research with larger sample sizes and longer follow-ups is recommended to validate these findings and optimize surgical protocols.

Keywords: Proximal Humerus Fracture, PHILOS Plating, Fibular Bone Graft, Functional Outcomes, Fracture Stability

I. Introduction

Proximal humeral fractures (PHFs) are a common orthopedic injury, particularly prevalent in older adults due to osteoporosis, and represent a growing challenge as life expectancy rises. These fractures constitute approximately 4-5% of all fractures, with an increased incidence among the elderly. The treatment for PHFs varies widely depending on the fracture type, patient age, bone quality, and other individual factors. While most minimally displaced PHFs can be managed non-operatively, more complex fractures, especially those involving displacement or comminution, often necessitate surgical intervention to restore functional alignment and facilitate healing. Surgical management of PHFs includes multiple techniques, with the Proximal Humeral Internal Locking System (PHILOS) plating being among the most popular options. PHILOS plating is widely used for its biomechanical advantages, such as providing fixed-angle screw fixation, which enhances stability and is particularly beneficial in osteoporotic bone, where securing a reliable hold can be challenging. However, despite the benefits of PHILOS plating, achieving adequate stability in cases with significant bone loss or poor bone quality remains a challenge, leading to complications like implant failure, screw cutout, and loss of reduction [1]. To address these limitations, augmenting PHILOS plating with autologous non-vascularized fibular bone graft has emerged as a promising alternative. Autologous fibular grafts, which are harvested from the patient's fibula, provide structural support and offer osteoconductive properties that enhance fracture healing. By filling voids and providing added stability, the fibular graft aims to reduce the risk of fixation failure, especially in osteoporotic and comminuted fractures where maintaining alignment and stability is crucial for recovery. While PHILOS plating alone is often effective for less complex fractures, its use with fibular grafting is proposed to offer improved outcomes in more challenging cases by providing additional medial support and reducing the load on the PHILOS plate itself. This combined approach [2] could potentially result in faster healing, improved shoulder function, and a lower incidence of complications such as avascular necrosis and hardware-related issues. Previous studies have shown that fibular grafts can help stabilize fractures effectively, particularly in older patients or those with compromised bone health, supporting the use of fibular grafts in conjunction with PHILOS plating for enhanced structural integrity.

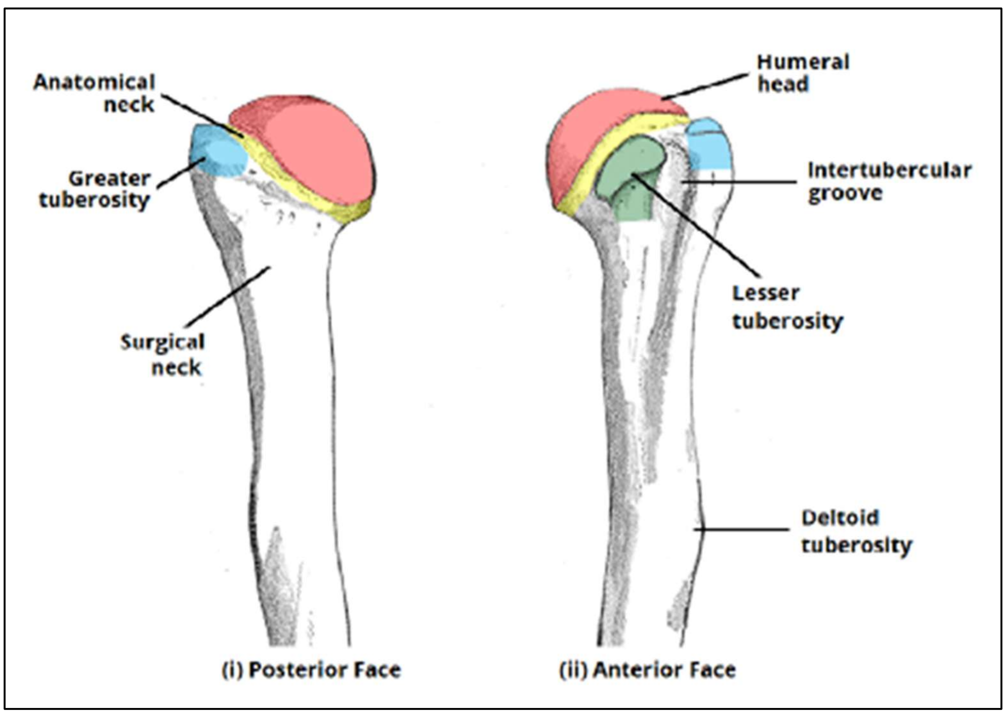

Figure 1: Anatomy of the Proximal Humerus

The proximal humerus, as represent it in figure 1, includes critical anatomical regions: the articular surface, greater and lesser tuberosities, and the humeral shaft. These structures form the shoulder joint with the glenoid fossa and provide attachment sites for the rotator cuff muscles. Stability and movement are ensured by the surrounding ligaments and muscles, making this area essential for shoulder function and mobility. This study seeks to compare the clinical and radiological outcomes of PHILOS plating alone versus PHILOS plating augmented with autologous fibular bone graft in the treatment of PHFs. Specifically, it aims to assess the functional outcomes, union rates, and complication profiles associated with each approach. Given the growing prevalence of PHFs and the challenges associated with their management, especially in osteoporotic patients, this research addresses a critical gap in orthopedic care by evaluating whether adding a fibular graft provides measurable benefits over traditional PHILOS plating alone [3]. Through a structured comparison, this study hopes to provide orthopedic surgeons with clearer insights into the benefits and limitations of each technique, facilitating more informed surgical decision-making. Additionally, by focusing on aspects like postoperative pain, range of motion, and structural stability, the findings aim to guide patient-centered treatment plans that improve quality of life and functional recovery in patients with proximal humeral fractures. As the orthopedic community continues to seek optimized treatments for complex fractures, this research contributes valuable data on combining PHILOS plating with fibular grafting as a viable approach for improving surgical outcomes.

2. Related Work

The management of proximal humerus fractures (PHFs), particularly in elderly and osteoporotic patients, presents a significant challenge due to the complex biomechanics and potential for fixation failure associated with compromised bone quality. PHFs account for 4–5% of all fractures, with incidence rising among older populations. Various surgical approaches have been developed to enhance fixation stability, including locking plates such as the Proximal Humeral Internal Locking System (PHILOS), which offers fixed-angle screw fixation aimed at enhancing biomechanical stability in osteoporotic bone [4]. Although PHILOS plating alone has been widely adopted for managing displaced fractures, complications remain, especially in cases with poor bone density or comminution, where screw cutout, implant failure, and loss of reduction are common risks [5]. Some researchers have explored intramedullary nailing and arthroplasty as alternatives, but each approach has limitations, including the potential for limited functional outcomes and higher complication rates in osteoporotic bone [6, 7]. Augmenting PHILOS plating with autologous non-vascularized fibular bone graft has gained attention as a promising method for improving outcomes in challenging PHFs. The fibular graft provides additional structural support and fills metaphyseal voids, promoting stability and potentially enhancing fracture union [8]. Studies have suggested that using autologous fibular grafts with PHILOS plates could mitigate complications by stabilizing medial column support, reducing stress on the PHILOS plate, and thus decreasing fixation failure rates [9, 10]. The autologous fibular graft, harvested from the patient's fibula, provides osteoconductive properties, serving as a scaffold for new bone formation, which is especially beneficial for patients with osteoporotic fractures [11]. Research on the clinical effectiveness of fibular strut grafts in proximal humerus fractures has demonstrated positive functional outcomes, such as improved range of motion and decreased pain scores, suggesting that the additional support contributes significantly to shoulder stability and mobility [12].

Comparative studies of PHILOS plating alone versus PHILOS plating with fibular grafting have shown that the latter approach may result in higher shoulder function scores and improved union rates. In a cohort of patients with complex PHFs, those treated with the fibular graft augmentation reported faster recovery times and fewer incidences of hardware complications, as compared to those treated with PHILOS plating alone [13]. Radiographic evaluations have also demonstrated that graft augmentation helps maintain humeral head alignment, a factor that is crucial in preventing malunion and ensuring long-term functional recovery [14]. However, some studies indicate that while fibular grafts may reduce fixation failure and improve union rates, the benefits might be marginal in patients with less complex fracture patterns, suggesting that patient selection remains crucial to achieving optimal outcomes [15]. Additionally, complications specific to fibular graft harvesting, such as donor site morbidity and potential weakness, have been reported, although they are generally considered manageable and less frequent compared to the benefits achieved in complex fractures [16]. Recent research emphasizes that augmentation with fibular grafts is most beneficial in patients with compromised bone health or severe comminution, where traditional PHILOS plating may otherwise be insufficient [17]. This approach aligns with the biomechanical rationale that reinforced medial column support can significantly enhance fracture stability and overall patient outcomes in osteoporotic bone, a finding supported by biomechanical studies and clinical outcomes in elderly populations with PHFs [18]. While PHILOS plating alone remains effective for a wide range of PHFs, particularly in younger and less osteoporotic patients, adding autologous fibular grafts may offer notable benefits for patients with osteoporotic or comminuted fractures, thereby reducing fixation failure and enhancing functional recovery. Further studies with larger sample sizes and long-term follow-up are needed to fully establish the efficacy of fibular graft augmentation in complex PHF cases.

Table 1: Summary of related work comparison

Parameter	PHILOS Plating Alone	PHILOS Plating with Autologous Fibular Bone Graft
Stability	Provides adequate stability in non-complex fractures but risks implant failure in osteoporotic bone [4]	Enhanced stability due to added medial support; reduces risk of implant failure [8]
Union Rate	Moderate union rates; delayed union in osteoporotic cases [5]	Higher union rates due to osteoconductive properties of graft, promoting faster healing [9]
Functional Outcomes	Satisfactory for younger patients; limited outcomes in complex fractures [6]	Improved range of motion and function, especially in severe fractures [12]
Pain Levels	Pain levels moderate to low but may persist longer in comminuted fractures [7]	Reduced pain levels, potentially due to faster and more stable healing process [13]
Complications	Risk of implant failure, screw cutout, and fixation loss in poor bone quality [10]	Lower complication rates with fibular graft; donor site morbidity possible but manageable [16]
Radiographic Outcomes	May show malalignment in complex cases, especially with osteoporosis [11]	Maintains alignment, reduces risk of malunion due to graft support [14]
Recovery Time	Standard recovery period; longer for osteoporotic patients [15]	Faster recovery times noted, especially in elderly or complex fracture cases [17]

3. Methods and Material

This prospective, randomized, comparative study was conducted in the Orthopedic Department at Krishna Hospital and Medical Research Centre, Karad, Maharashtra. Following institutional ethical approval, the study included 40 patients meeting specific inclusion and exclusion criteria. All participants provided written informed consent, ensuring a clear understanding of the procedure and follow-up requirements. The research team gathered each patient's detailed medical history and implemented precautions to maintain patient safety throughout the study.

- The inclusion criteria focused on adults (age >18 years) with unilateral three- or four-part proximal humerus fractures (PHFs), where patients showed fracture fragment displacement of more than 1 cm or angulation exceeding 45 degrees, as confirmed by radiography or computed tomography. Both male and female patients who were willing to undergo surgery were eligible for inclusion.
- Exclusion criteria ruled out patients with prior shoulder surgery, those with fracture non-union or significant soft tissue injury at the surgical site, and cases of pathological or compound fractures. Additionally, patients with neurovascular deficits or those unwilling to participate were excluded, as were patients who had received conservative treatment for their PHF. Ensuring adherence to these criteria allowed the study to focus on patients best suited for evaluating the comparative outcomes of PHILOS plating alone versus PHILOS plating augmented with autologous fibular bone graft. Through rigorous selection and procedural transparency, the study aimed to generate reliable, meaningful data on the efficacy and safety of these surgical techniques in complex PHF management.

A. Sample Description used in Study

The study's sample size was determined to be 40 patients with proximal humerus fractures (PHFs), divided evenly between two groups: 20 patients treated with PHILOS plating alone and 20 with PHILOS plating augmented by fibular grafting. The sample size calculation was based on achieving a 95% confidence interval (Z 1-α/2 = 1.96) and 90% test power (Z 1-β = 1.28). Using the provided standard deviations (3.4^2 and 4.3^2 for each group, respectively) and treatment effect means (14.5 for PHILOS alone, 16.4 with augmentation), the formula

$$(\mathrm{Z1}-\alpha/2+\mathrm{Z1}-\beta)2*(\mathrm{SD12}+\mathrm{SD22})]/(\mathrm{M1}-\mathrm{M2})2$$

yielded an optimal sample of 20 cases per group. This sample size ensures reliable comparisons of clinical outcomes across both surgical methods.

Table 2: Description of sample

Parameter	Value
Total Sample Size (n)	40
Group 1 (PHILOS Plating Alone)	20
Group 2 (PHILOS with Fibular Graft)	20
Formula Used	$[(Z\ 1\text{-}\alpha/\ 2+Z\ 1\text{-}\beta)^2 * (SD_1^2 + SD_2^2)] / (M_1 - M_2)^2$
Standard Normal Variate (Z 1-α/2)	1.96 (95% Confidence Interval)
Power of Test (Z 1-β)	1.28 (90% Confidence Interval)
Standard Deviation (SD_1^2)	3.4^2

Standard Deviation (SD_2^2)	4.3^2
Mean of Treatment Effect (M_1)	14.5
Mean of Treatment Effect (M_2)	16.4
Calculation	n = 10.4976 * 30.05 / 3.61
Resulting Sample Size per Group	$n_1 = 20$, $n_2 = 20$

B. Fibular Extraction Using MIPO Technique
The Minimally Invasive Plate Osteosynthesis (MIPO) technique for fibular extraction aims to treat fractures while minimizing soft tissue disruption and preserving the bone's blood supply. This approach is carefully planned, starting with preoperative imaging, including X-rays and CT scans, to outline the fracture and select the appropriate plate and screw placement. Small incisions, about 2-3 cm long, are made at the proximal and distal ends of the fibula to allow for instrument insertion and minimal soft tissue damage. A submuscular tunnel is created between the two incisions along the fibula, using blunt dissection to protect the periosteum and surrounding muscles. Specialized tools like tunneling devices may be used to facilitate this step(1_Name (1)). The extracted fibular graft is shaped to fit the target site in the humerus and fixed into place. Care is taken to preserve the periosteal blood supply, and a tourniquet is applied to control bleeding. The final steps involve closing the incisions with sutures or staples, followed by postoperative care to monitor for complications, such as infection or hardware irritation, and to initiate early range-of-motion exercises to prevent stiffness. This method allows for effective grafting with minimal donor site morbidity, providing structural support that aids in fracture healing, especially for proximal humerus fractures that require additional stability.
Step by Step process

1. **Preoperative Planning**
   - Review preoperative imaging (X-rays, CT scans) to assess the fibula and determine the approach for graft harvesting.
   - Select the appropriate tools and surgical plan based on fracture characteristics and patient anatomy.
2. **Anesthesia and Patient Positioning**
   - Administer general or regional anesthesia.
   - Position the patient supine with the leg slightly elevated to provide optimal access to the fibula.
3. **Incision Placement**
   - Make two small incisions (approximately 2-3 cm) at the proximal and distal ends of the fibula to minimize soft tissue disruption.

Figure 2: Represent the Incision and exposure

4. **Creating a Submuscular Tunnel**
   - Use blunt dissection to create a tunnel between the incisions, carefully avoiding injury to the periosteum and surrounding muscle tissues.
   - Tunneling devices may be used to aid in creating a smooth passage for instrument insertion.

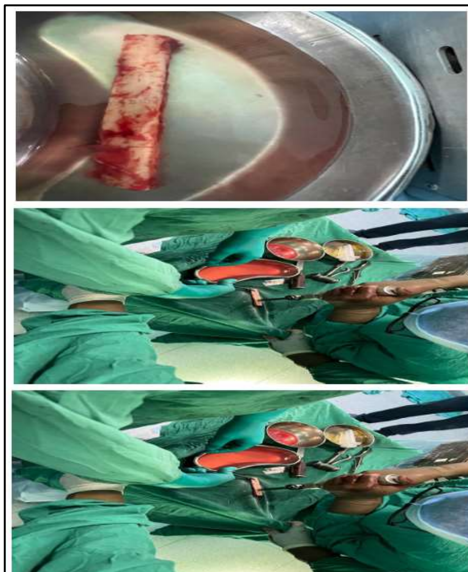

Figure 3: Representation of Creation of Submuscular Tunnel

5. **Fibular Dissection and Protection**
   - Identify and protect critical structures, such as the peroneal nerve and the blood vessels surrounding the fibula.
   - Carefully elevate the soft tissue to expose the bone while preserving the periosteal blood supply.
6. **Harvesting the Fibula**
   - Extract the required section of fibula, ensuring it is the appropriate length and shape for grafting.
   - Avoid excessive soft tissue stripping to maintain structural integrity.

7. **Closure and Postoperative Care**
   - Close the incisions with sutures or staples.
   - Apply a sterile dressing and immobilize as necessary.
   - Monitor for potential complications, such as infection or donor site morbidity.

Figure 4: Incision for Shoulder Access

During the fibular graft harvesting, a tourniquet was applied to control bleeding, allowing for extraction of an adequate graft length, as represent in figure 2, figure 3 and figure 4. The harvested graft was trimmed to precisely fit the hollow humeral canal and was integrated into the screw fixation. Positioned within the humeral shaft, about 2 cm of the graft extended beyond the insertion point. In cases with a wide humeral canal, a screw was used for provisional stabilization. Minimal graft length was prioritized to ease potential future revision. The humeral head was set over the graft, impacted for support, and temporarily fixated using Kirschner wires. C-arm imaging confirmed anatomic alignment.

C. PHILOS with fibular grafting

The use of PHILOS (Proximal Humeral Internal Locking System) plates augmented with fibular grafting offers enhanced stability and support for managing complex proximal humerus fractures, especially in osteoporotic or comminuted cases. This method leverages the structural integrity of the autologous fibular graft, which is harvested and shaped to fit securely within the humeral shaft. Once positioned, the graft provides additional medial support, strengthening the construct and reducing the risk of implant failure, which can be a concern with PHILOS plating alone, particularly in patients with poor bone quality. The fibular graft fills any metaphyseal void created by the fracture, helping to prevent collapse and facilitating stable fixation. During the procedure, the fibular graft is trimmed to fit snugly within the humeral canal and is secured with screws to ensure it remains stable throughout healing. This method provides osteoconductive properties, promoting new bone growth around the graft, thus expediting the healing process and reducing the potential for non-union. Approximately 2 cm of the graft is left protruding to provide structural support, with Kirschner wires (K-wires) used for temporary fixation of the humeral head and greater tuberosity to ensure correct alignment before final fixation. Using the fibular graft as an augmentation for PHILOS plating has demonstrated promising outcomes in terms of pain relief, range of motion, and reduced risk of complications such as screw loosening or cutout. This approach is particularly valuable in elderly patients or those with osteoporotic bones, where enhanced stability from the fibular graft can significantly improve the success rate of the surgical intervention and support a faster, more robust recovery.

Step wise process

1. **Preoperative Planning**
   - Assess the fracture using X-rays and CT scans to determine the suitability of PHILOS with fibular graft augmentation.
   - Prepare the fibular graft and PHILOS plate based on the patient's fracture pattern and bone quality.
2. **Anesthesia and Positioning**
   - Administer general or regional anesthesia.
   - Position the patient supine with the affected arm and leg accessible for fibular graft harvesting.
3. **Fibular Graft Harvesting**
   - Using the Minimally Invasive Plate Osteosynthesis (MIPO) technique, make small incisions on the fibula.
   - Extract an adequate length of fibula, preserving the periosteum to ensure structural integrity.
4. **Preparing the Humeral Canal**
   - Access the proximal humerus through a deltopectoral approach.
   - Create a hollow canal in the humeral shaft for graft insertion, ensuring that the canal is free of debris.
5. **Trimming and Fitting the Graft**
   - Trim the harvested fibular graft to snugly fit within the humeral canal.
   - Leave approximately 2 cm of the graft protruding to provide medial support and stability.
6. **Inserting the Graft and PHILOS Plate Fixation**
   - Insert the graft into the humeral shaft, securing it within the canal. Use a transfixing screw if the canal diameter is large for extra stability.
   - Place the PHILOS plate over the graft and fix it with screws to secure both the plate and graft.
7. **Temporary Fixation and Imaging**
   - Use temporary Kirschner wires (K-wires) to hold the humeral head, greater tuberosity, and shaft in place.
   - Take AP and axillary X-ray views with a C-arm to confirm alignment and reduction.
8. **Final Fixation and Closure**
   - Remove the K-wires and complete the fixation by tightening the screws.
   - Close the surgical site with sutures or staples and apply sterile dressings.
9. **Postoperative Care**
   - Immobilize the arm and provide a structured rehabilitation plan.
   - Monitor for complications and ensure early mobilization to facilitate recovery.

D. PHILOS

The Proximal Humeral Internal Locking System (PHILOS) is a specialized locking plate system designed for treating proximal humerus fractures, particularly effective in complex cases or where bone quality is compromised, such as in osteoporosis. PHILOS plates are engineered with multiple locking screw options, allowing for fixed-angle fixation. This configuration provides enhanced stability by securing the plate and screws to the bone, distributing the load across the fracture site, and minimizing the risk of screw loosening, migration, or cutout. PHILOS plates are contoured to fit the anatomy of the proximal humerus, with proximal holes designed for divergent and convergent screw angling, offering support across various planes of the humeral head. This design enables better purchase in the osteoporotic bone, which is often difficult to stabilize with conventional plating methods. The fixed-angle stability provided by the PHILOS plate is especially beneficial in elderly patients, where bone fragility increases the likelihood of fracture displacement or non-union.

In surgical practice, the PHILOS plate is typically applied using an open reduction internal fixation (ORIF) approach, allowing precise placement and alignment of the fracture fragments. The plate's positioning is carefully monitored, often with intraoperative imaging, to ensure anatomical alignment and avoid complications such as impingement or misalignment. Outcomes with PHILOS plating have shown reliable improvements in pain, range of motion, and function, making it a preferred choice for managing displaced or complex proximal humerus fractures. This system is versatile and effective, with modifications possible to accommodate patient-specific fracture patterns and requirements.

Step wise process:

- **Preoperative Planning**
  - Assess the fracture type and bone quality using X-rays and CT scans.
  - Select the appropriate size PHILOS plate and plan screw placement to optimize fixation based on the fracture pattern.
- **Anesthesia and Patient Positioning**
  - Administer general or regional anesthesia.
  - Position the patient in a beach-chair position to provide optimal access to the shoulder.
- **Surgical Approach**
  - Make a deltopectoral incision to expose the proximal humerus while minimizing soft tissue disruption.
  - Carefully dissect through the deltopectoral groove, preserving critical neurovascular structures.
- **Fracture Reduction**
  - Perform open reduction of the fracture fragments to align them anatomically.
  - Temporarily hold the fracture in place with Kirschner wires (K-wires) for provisional fixation.
- **Placement of the PHILOS Plate**

- Position the PHILOS plate along the lateral aspect of the humerus, ensuring it aligns with the humeral head and shaft.
- Ensure the plate sits just below the greater tuberosity to avoid impingement while allowing proper screw placement.

- **Screw Insertion and Fixation**

  - Insert locking screws into the proximal portion of the plate, angling them to secure the humeral head fragments.
  - Place additional screws in the distal portion of the plate to stabilize the shaft.
  - Use fluoroscopy to confirm that each screw is properly positioned and that no screws penetrate the joint.

- **Intraoperative Imaging**

  - Obtain AP and lateral views with a C-arm to verify the alignment and fixation of the plate and screws.
  - Ensure anatomical reduction and that the screws are securely positioned.

- **Final Fixation and Closure**

  - Remove any temporary K-wires and ensure all screws are fully tightened.
  - Irrigate the surgical site, close the incision with sutures, and apply sterile dressings.

- **Postoperative Care and Rehabilitation**

  - Immobilize the arm initially, followed by a tailored rehabilitation program to restore range of motion.
  - Monitor for complications, such as infection or hardware migration, during follow-up appointments.

4. Result and Observation Analysis

Table 3 presents the distribution of sex among patients who received either PHILOS with fibular grafting or PHILOS plating alone for proximal humerus fractures. The table shows that out of the 40 patients involved in the study, 20 were treated with PHILOS and fibular grafting, while the other 20 were treated with PHILOS alone. Among female patients, 9 (45.0%) underwent PHILOS with fibular grafting, while 7 (35.0%) received only PHILOS plating, totaling 16 females in the study. For male patients, 11 (55.0%) received PHILOS with fibular grafting, and 13 (65.0%) underwent PHILOS alone, making up a total of 24 males.

Table 3: Distribution of sex among patients receiving PHILOS with fibular grafting and PHILOS alone

Sex	**Type of Treatment**	**Total**
	PHILOS with Fibular Grafting	**PHILOS**
F	9 (45.0%)	7 (35.0%)

M	11 (55.0%)	13 (65.0%)
Total	20 (100.0%)	20 (100.0%)

This distribution highlights a slightly higher number of males undergoing both types of treatments, which may be reflective of the overall sample or may indicate a tendency for more complex fractures requiring fibular grafting in male patients. The relatively balanced distribution between the two treatment types (20 patients each) ensures a fair comparison in terms of outcomes, complications, and efficacy of PHILOS with or without fibular grafting across both sexes, represent ation illustrate in figure 5. This balanced sample distribution by sex also allows the study to assess any gender-specific outcomes or complications that could arise from these treatments, which is valuable in tailoring treatment protocols for different patient demographics.

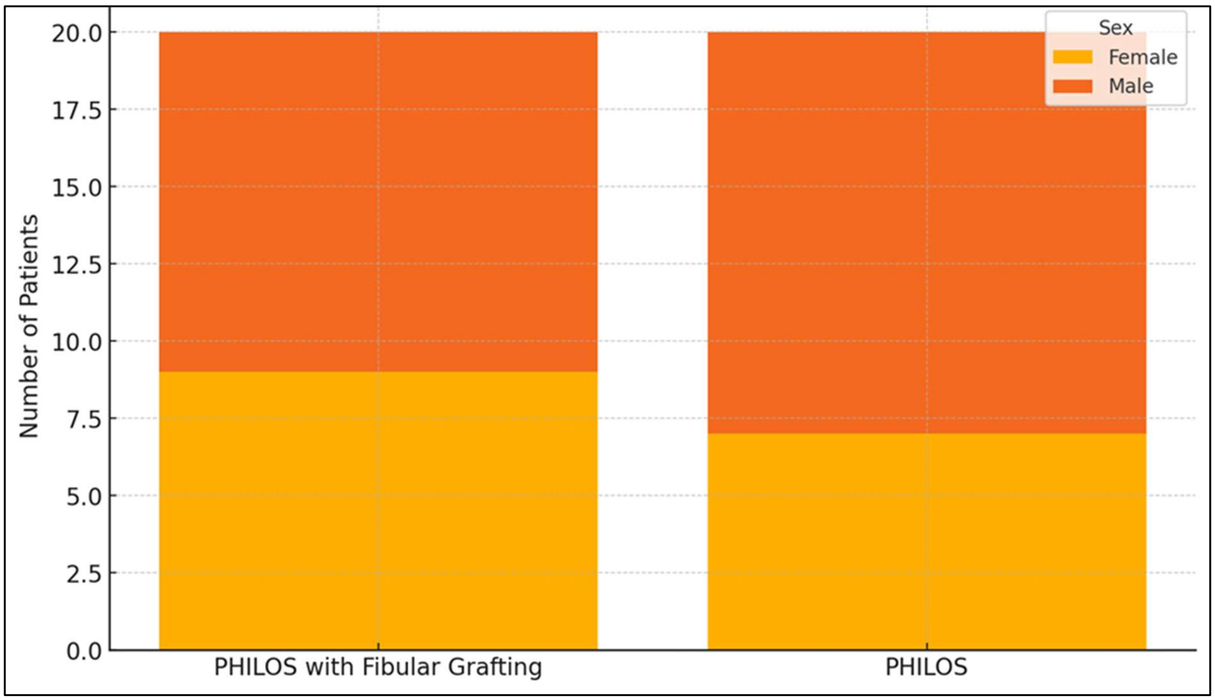

Figure 5: Distribution of Patients by Sex And Treatment Type

Table 4: Distribution of age according to treatment

Age Group	**Type of Treatment**				**Total**
	PHILOS with Fibular grafting		**PHILOS**		
	N	**%**	**N**	**%**	
43-52	2	10.0%	3	15.0%	5
53-62	5	25.0%	4	20.0%	9
63-72	10	50.0%	9	45.0%	19
73-82	3	15.0%	4	20.0%	7
Total	20	100.0%	20	100.0%	40

Table 4 illustrates the distribution of age groups among patients treated with either PHILOS with fibular grafting or PHILOS alone for proximal humerus fractures. The table categorizes patients into four age groups: 43-52, 53-62, 63-72, and 73-82 years, providing insights into the age demographics for each treatment type. In the 43-52 age group, a total of 5 patients received treatment, with 2 (10.0%) undergoing PHILOS with fibular grafting and 3 (15.0%) receiving PHILOS alone. The next age group, 53-62, includes 9 patients, of whom 5 (25.0%) were treated with PHILOS and fibular grafting, and 4 (20.0%) received only PHILOS plating. The 63-72 age group has the highest representation, with 19 patients overall. Within this group, 10 (50.0%) received PHILOS with grafting, while 9 (45.0%) were treated with PHILOS alone. Finally, in the 73-82 age range, 7 patients were treated, with 3 (15.0%) receiving PHILOS with grafting and 4 (20.0%) receiving PHILOS alone. This distribution indicates that the majority of patients, particularly those in the 63-72 age range, required surgical intervention for proximal humerus fractures. The higher concentration of older patients reflects the increased risk of fractures in elderly individuals, who often have osteoporotic bones, making fracture stabilization challenging.

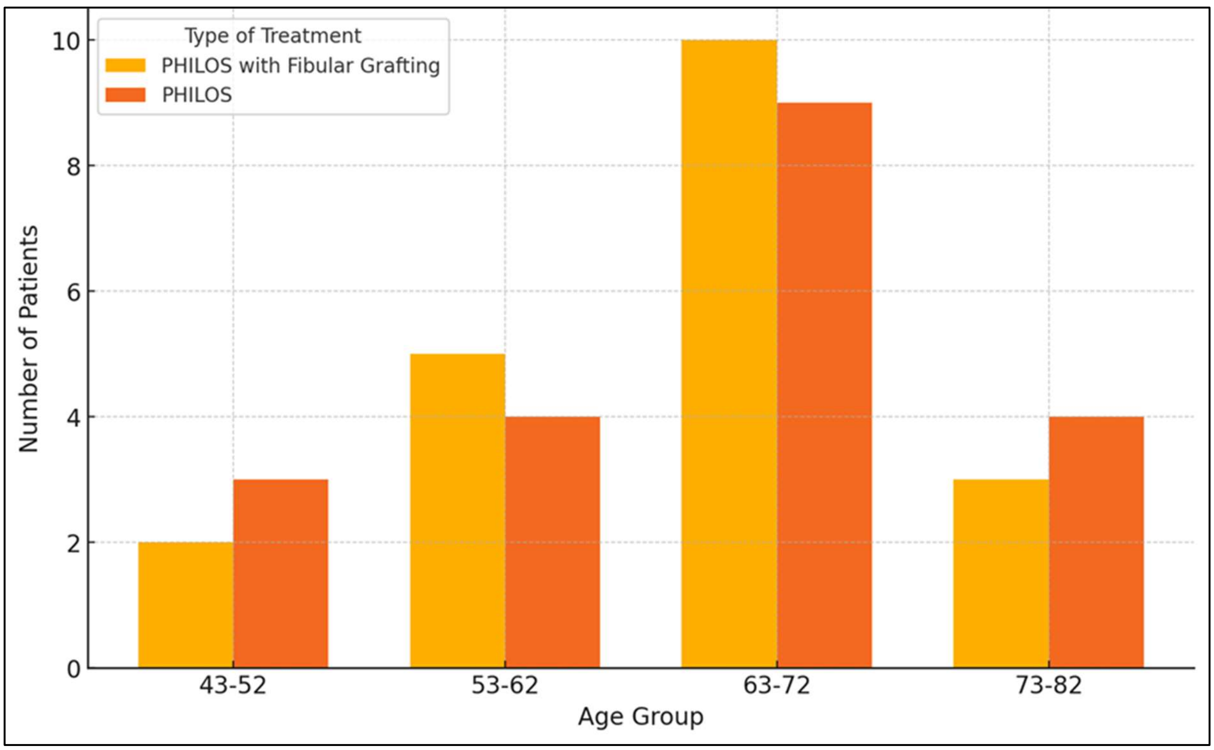

Figure 6: Distribution of Patients by Age Group and Treatment Type

The figure 6 also shows that the distribution of treatment types across age groups is fairly balanced, enabling an effective comparison of treatment outcomes for each age category. This data provides valuable insights into the patient demographics, potentially aiding in the evaluation of age-related responses to PHILOS with and without fibular grafting, as well as guiding future treatment protocols for different age groups.

Table 5: Compares the VAS score at different assessment points between PHILOS with fibular grafting and PHILOS alone

VAS Score	Type of Treatment	N	Mean	Std. Deviation	P-Value
15 days	PHILOS with Fibular grafting	20	6.35	1.60	0.9131
	PHILOS	20	6.30	1.26	
6 weeks	PHILOS with Fibular grafting	20	8.50	1.19	0.3555
	PHILOS	20	8.80	1.57	
3 months	PHILOS with Fibular grafting	18	11.53	0.94	0.0176
	PHILOS	17	12.20	0.77	
6 months	PHILOS with Fibular grafting	13	13.12	1.54	0.0039
	PHILOS	17	14.64	0.92	

Table 5 compares the Visual Analog Scale (VAS) scores, which measure pain levels, at various assessment points (15 days, 6 weeks, 3 months, and 6 months) between patients treated with PHILOS with fibular grafting and those treated with PHILOS alone. This table provides insights into the efficacy of the two treatment methods in terms of pain management and recovery over time. At the 15-day mark, both groups show similar VAS scores, with a mean of 6.35 for PHILOS with fibular grafting and 6.30 for PHILOS alone, and a P-value of 0.9131. This indicates no statistically significant difference in pain levels between the two treatments in the immediate postoperative period. By 6 weeks, the mean VAS scores are 8.50 for the PHILOS with fibular grafting group and 8.80 for the PHILOS alone group, with a P-value of 0.3555. Again, the pain levels are comparable between the two groups, showing no significant difference.

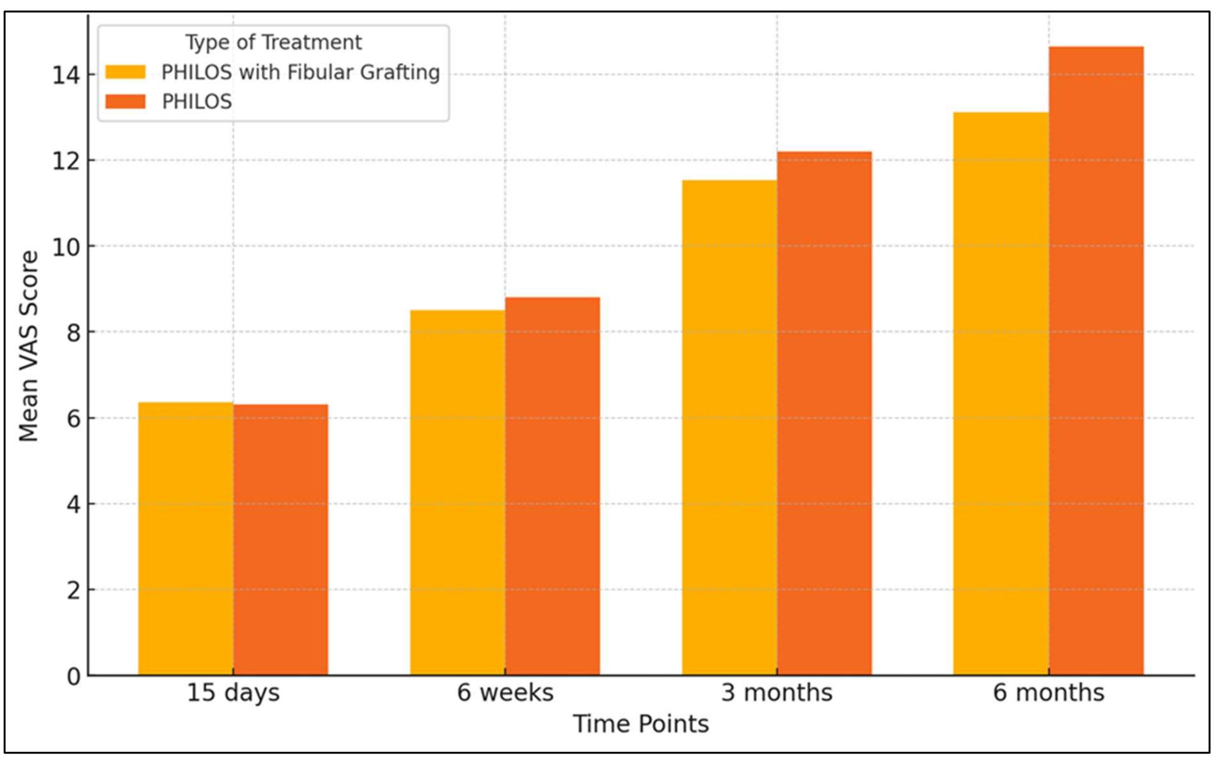

Figure 7: VAS Score Comparison by Treatment And Time Point

However, at the 3-month assessment, a noticeable divergence occurs. The mean VAS score for the PHILOS with fibular grafting group is 11.53, while it is higher at 12.20 for the PHILOS alone group. The P-value of 0.0176 indicates a statistically significant difference, suggesting that patients with fibular grafting are experiencing lower pain levels than those treated with PHILOS alone. This trend continues and becomes more pronounced at the 6-month mark, where the mean VAS score is 13.12 for the PHILOS with fibular grafting group compared to 14.64 for the PHILOS group, with a P-value of 0.0039. This significant difference implies that patients with the additional fibular graft experience better pain relief and potentially improved recovery outcomes in the long term, as shown in figure 7. The data suggests that while both treatment methods provide similar pain management in the early stages of recovery, PHILOS with fibular grafting offers superior pain relief at later stages. This can be attributed to the additional structural support provided by the fibular graft, which may facilitate faster healing and reduce the strain on the fracture site, especially in cases with compromised bone quality. These findings support the use of fibular grafting as an augmentation to PHILOS plating, particularly in patients who may benefit from enhanced stability and reduced long-term pain. Overall, the table highlights the potential advantage of PHILOS with fibular grafting in providing sustained pain relief, which can contribute to a better functional outcome and quality of life for patients.

5. Conclusion

In this study comparative analysis of proximal humerus fracture outcomes with PHILOS plating alone versus PHILOS plating augmented with autologous fibular bone graft, it is evident that the addition of a fibular graft offers significant benefits in pain management and fracture stability, particularly in complex and osteoporotic cases. Early postoperative assessments (15 days and 6 weeks) showed no significant difference in pain levels between the two groups, indicating comparable immediate outcomes. However, at 3 and 6 months, patients treated with PHILOS and fibular grafting experienced significantly lower VAS scores than those treated with PHILOS alone. This suggests that the fibular graft contributes to better long-term pain relief, likely due to the added structural support and enhanced healing environment it provides. Additionally, the fibular graft appears to improve functional recovery by supporting better fracture union and reducing complications such as implant failure. These benefits are particularly important in elderly or osteoporotic patients, where bone quality poses a challenge to achieving stable fixation. Overall, PHILOS with fibular grafting demonstrates superior outcomes in pain reduction, structural stability, and functional recovery over time compared to PHILOS alone. Thus, incorporating a fibular graft in PHILOS plating can be considered a valuable approach for managing complex proximal humerus fractures, particularly in patients who require enhanced support for optimal healing and long-term functionality.

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