Deltoid-Splitting versus Deltopectoral Approach for PHILOS Plate Fixation in Neer Type II and III Proximal Humerus Fractures: A Prospective Randomized Comparative Study

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ABSTRACT
Background: Proximal humerus fractures (PHFs) account for 4–7% of all adult fractures. While PHILOS locking plate fixation is well established, the optimal surgical approach — deltopectoral (DP) versus deltoid-splitting (DS) — remains debated. This prospective randomized study aimed to compare perioperative, functional, and radiological outcomes between the two approaches.
Methods: Sixty patients with displaced Neer type II or III PHFs were randomized to DP (n=30) or DS (n=30) PHILOS plate fixation at a tertiary centre in Southern India. Primary outcomes included operative time, intraoperative blood loss, postoperative pain (VAS), functional recovery (Q-DASH), radiological alignment (Hertel head–shaft angle), fracture union (Allman's score), range of motion, and complications at 6 weeks, 3 months, and 6 months.
Results: Groups were matched for age, sex, fracture type, and mechanism of injury. Operative time (85.2±5.73 vs 101.8±8.07 min; $p<0.001$) and blood loss (158±14.24 vs 224.8±28.15 mL; $p<0.001$) were significantly lower in the DS group. The DS group achieved a superior head–shaft angle (136.5°±7.24 vs 131.97°±6.79; $p=0.015$), lower VAS pain scores at all time points, and significantly better Q-DASH scores at 6 weeks, 3 months, and 6 months (all $p<0.001$). Shoulder range of motion at 6 months was significantly greater in the DS group. Allman's score indicated faster early union at 6 weeks ($p=0.003$); complete union was universal at 6 months. Overall complication rate was lower in the DS group (6.7% vs 16.7%); no avascular necrosis was observed.
Conclusion: Both approaches are safe and reliably achieve complete union. The deltoid-splitting technique confers significant advantages in operative efficiency, fracture alignment, postoperative pain, functional recovery, and complication profile, supporting its preferential use in appropriately selected patients..
Keywords: proximal humerus fracture; PHILOS plate; deltoid-splitting approach; deltopectoral approach; locking plate fixation; functional outcome.
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INTRODUCTION
Proximal humerus fractures (PHFs) are among the most common fractures involving the upper extremity and account for approximately 4–7% of all adult fractures worldwide.[1] The epidemiology of these injuries has evolved considerably over recent decades, with population-based studies demonstrating a steady increase in incidence, particularly among elderly individuals.[2] This rise has been attributed to increasing life expectancy, reduced bone mineral density, and a growing prevalence of osteoporosis in ageing populations.[3] In many countries, proximal humerus fractures rank as the third most common osteoporotic fracture after fractures of the hip and distal radius.[4]
The majority of PHFs occur following low-energy falls onto an outstretched hand, especially in postmenopausal

women with osteoporotic bone.[5] These fractures frequently result in significant pain, limitation of shoulder movement, prolonged functional impairment, and reduced quality of life. Consequently, they represent an important socioeconomic and healthcare burden because many affected patients require prolonged rehabilitation and assistance with activities of daily living.[4]

The proximal humerus consists of the humeral head, greater tuberosity, lesser tuberosity, and surgical neck, which collectively contribute to the complex biomechanics of the shoulder joint. Preservation of the vascular supply to the humeral head is essential for successful fracture healing and maintenance of joint function. Disruption of the blood supply following trauma or surgical intervention may result in complications such as avascular necrosis, nonunion, and implant failure.[5]

Management of proximal humerus fractures depends on multiple factors including fracture configuration, degree of displacement, patient age, functional requirements, and bone quality. While minimally displaced fractures can often be treated conservatively, displaced Neer type II and III fractures frequently require operative intervention to restore anatomy and facilitate early mobilization.[1] Surgical options include percutaneous fixation, intramedullary nailing, open reduction and internal fixation, and arthroplasty in selected complex fractures.[6]

Among available fixation methods, the Proximal Humerus Internal Locking System (PHILOS) plate has emerged as one of the most widely accepted implants for displaced proximal humerus fractures.[6] The PHILOS plate provides angular stability through fixed-angle locking screws and offers enhanced fixation in osteoporotic bone. Clinical studies have demonstrated satisfactory union rates, restoration of alignment, and favorable functional outcomes following PHILOS plating in appropriately selected patients.[6]

The choice of surgical approach plays a critical role in determining fracture visualization, quality of reduction, preservation of soft tissues, and postoperative recovery. The deltopectoral approach remains the traditional and most commonly employed surgical approach for PHILOS fixation.[6] This approach provides excellent exposure of the proximal humerus and facilitates management of complex fracture patterns. However, it often requires extensive soft-tissue dissection and greater manipulation of the fracture fragments, which may increase operative time and blood loss.[6]

To minimize soft-tissue disruption, the deltoid-splitting approach has gained increasing popularity. This approach utilizes a direct lateral pathway through the raphe between the anterior and middle fibres of the deltoid muscle, thereby allowing more direct access to the lateral aspect of the proximal humerus.[7] Anatomical studies have demonstrated that careful identification and protection of the axillary nerve are essential during this procedure because of its close relationship to the operative field.[8]

Several clinical investigations have evaluated the effectiveness of the deltoid-splitting approach for PHILOS plate fixation. Early reports suggested that the approach provides adequate fracture exposure while minimizing soft-tissue stripping and preserving vascularity around the humeral head.[9] More recent systematic reviews and meta-analyses have reported shorter operative time, reduced blood loss, and improved early functional outcomes with the deltoid-splitting approach compared with the conventional deltopectoral approach.[10] A prospective randomized study by Rungchamrussopa et al. demonstrated that both approaches achieved satisfactory fracture union; however, the deltoid-splitting approach was associated with earlier functional recovery and less surgical morbidity.[11] Similarly, a meta-analysis by Yufeng et al. found that the deltoid-splitting approach resulted in improved early postoperative shoulder function while maintaining comparable complication rates.[12] Zhe et al. also reported favorable clinical outcomes and shorter operative duration with the deltoid-splitting technique.[13] Evidence from Indian studies has further supported the effectiveness of the deltoid-splitting approach, although variability in patient selection and outcome measures continues to limit definitive conclusions.[14]

Achievement of stable reduction remains a key determinant of successful outcomes after PHILOS fixation. Restoration of medial column support has been shown to reduce varus collapse, screw penetration, and fixation failure. Gardner et al. emphasized the importance of indirect medial reduction and structural support in maintaining fracture stability and improving healing outcomes.[15]

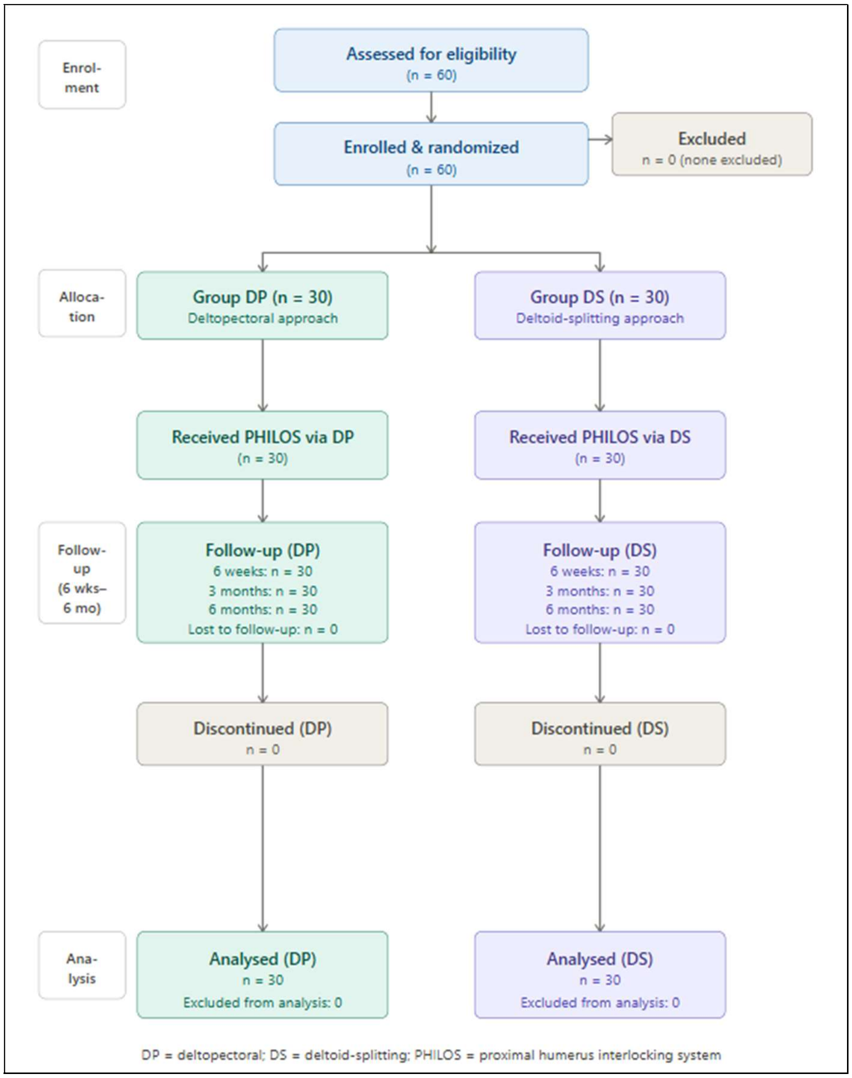
Despite increasing evidence supporting both surgical techniques, consensus regarding the optimal approach for PHILOS fixation of displaced proximal humerus fractures remains lacking. Variations in operative parameters, radiological outcomes, functional recovery, and complication rates continue to be reported across studies. Therefore, the present prospective randomized comparative study was undertaken to compare the deltopectoral and deltoid-splitting approaches for PHILOS plate fixation in Neer type II and III proximal humerus fractures. The study aimed to evaluate operative time, blood loss, fracture reduction quality, fracture union, postoperative pain, functional recovery, range of motion, and complications to determine the most effective surgical approach for these commonly encountered injuries.

2. METHODS

2.1 Study Design and Setting

This prospective, randomized, single-centre comparative study was conducted at SRM Medical College Hospital and Research Institute, a tertiary referral centre in Southern India, over a 24-month period (April 2024 – December 2026). Ethical approval was obtained from the Institutional Review Board, and written informed consent was secured from all participants prior to enrolment. The study adhered to the principles of the Declaration of Helsinki. The study enrolment, randomization, and allocation process are illustrated in the CONSORT-style flowchart (Figure 1).

Figure 1. CONSORT-style flow diagram illustrating patient enrolment, randomization, and allocation into deltopectoral (DP) and deltoid-splitting (DS) groups for PHILOS plate fixation of Neer type II and III proximal humerus fractures.



2.2 Participants

A total of 60 patients with displaced proximal humerus fractures (PHFs) fulfilling the inclusion criteria were enrolled. Inclusion criteria comprised adult patients (≥18 years) with closed physes and displaced Neer type II or III fractures, defined as displacement >1 cm and/or angulation >45°.

Exclusion criteria included open fractures, Neer type IV fractures with varus morphology, fracture-dislocations, head-split fractures, polytrauma involving the ipsilateral upper limb, associated neurological injury, prior ipsilateral shoulder surgery or pathology, cognitive impairment, inflammatory arthritis, active infection, and concurrent participation in another interventional trial.

2.3 Randomization

Participants were randomized in a 1:1 ratio to undergo open reduction and internal fixation (ORIF) via either the deltopectoral approach (Group DP; n = 30) or the deltoid-splitting approach (Group DS; n = 30). The sample size was calculated with reference to a previously published comparative randomized study[11], yielding a total sample size of 60 patients. Patients were positioned in the supine or beach-chair (semi-reclined) position to facilitate optimal surgical exposure

2.4 Surgical Technique

(Figure 2). Preoperative marking of anatomical landmarks was performed to guide incision placement **(Figure 3).**

Figure 2. Intraoperative photograph demonstrating patient positioning in the supine position (with slight head-end elevation) for proximal humerus fracture fixation.

Figure 3. Preoperative marking of anatomical landmarks for incision planning in proximal humerus fracture fixation.

Deltopectoral Approach (Group DP)

A 12–14 cm skin incision was made extending from the coracoid process to the proximal humeral shaft. The deltopectoral groove was identified along with the cephalic vein, which was retracted laterally. The clavipectoral fascia was incised lateral to the conjoined tendon, followed by lateral retraction of the deltoid and medial retraction of the conjoined tendon. The subscapularis tendon was identified and divided vertically lateral to the musculotendinous junction, and the joint was entered via a vertical capsulotomy. Fracture reduction was performed under fluoroscopic guidance, and provisional fixation was achieved using K-wires prior to PHILOS plate application **(Figure 4).**

Figure 4. Intraoperative image demonstrating PHILOS locking plate fixation via the deltopectoral approach.

Deltoid-Splitting Approach (Group DS)

A 5 cm longitudinal incision was made from the lateral border of the acromion extending distally along the humeral axis (Figure 5). The raphe between the clavicular and acromial fibres of the deltoid was identified, and the muscle was split along its fibres. The axillary nerve was identified and protected throughout the procedure.

Figure 5. Surface anatomical landmark identification and incision planning for the deltoid-splitting approach.

Fracture reduction was confirmed under fluoroscopy, and fixation was achieved using a PHILOS plate through the split approach (Figure 6).

Figure 6. PHILOS plate fixation performed via the deltoid-splitting approach with preservation of the axillary nerve.

Implant Characteristics

The PHILOS (Proximal Humerus Internal Locking System) plate was used in all cases **(Figure 7).** This pre-contoured, low-profile locking plate is designed to conform to the lateral aspect of the proximal humerus, minimizing subacromial impingement. The spatulated head contains multiple locking holes permitting divergent and convergent screw trajectories, thereby creating a three-dimensional scaffold for enhanced pull-out resistance

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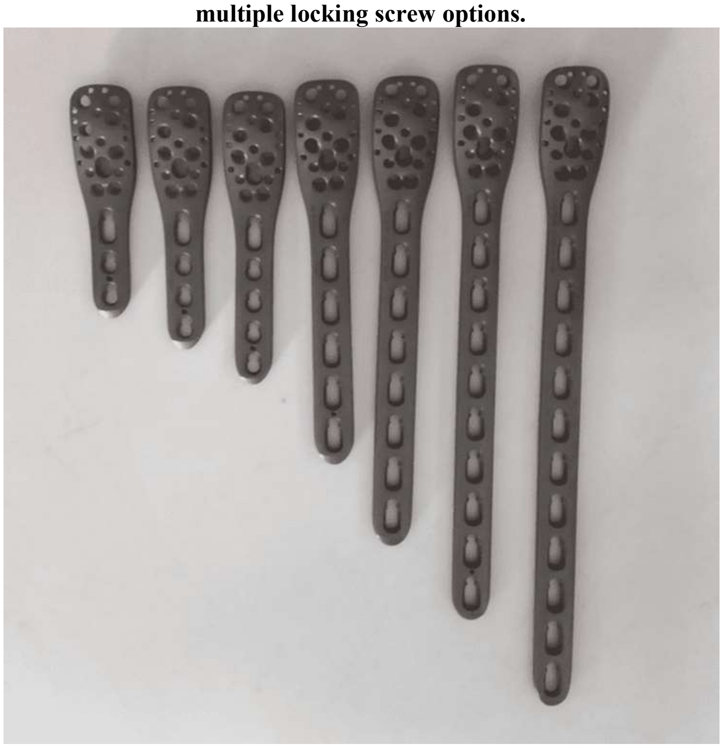
Figure 7. PHILOS (Proximal Humerus Internal Locking System) plate showing pre-contoured design and multiple locking screw options.



Cortical and cancellous screws used for fixation are illustrated in **Figure 8**, while the associated instrumentation, including screw handles, drill sleeves, T-handles, and K-wires, are shown in **Figure 9.**

Figure 8. Cortical and cancellous screws used in PHILOS plate fixation.

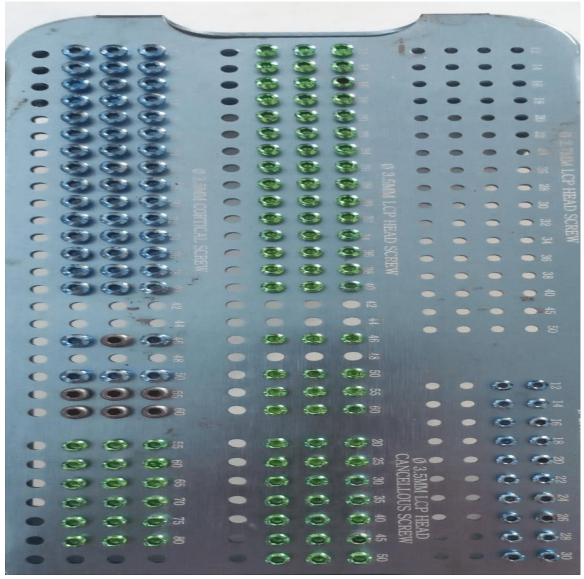


Figure 9. Instrumentation set including screw handles, drill sleeves, T-handles, and K-wires used during fixation.

Short PHILOS plates (3–5 holes; approximately 90–142 mm) were used for fractures without diaphyseal extension, whereas longer plates (≥6 holes; approximately 160–286 mm) were used for fractures with diaphyseal extension.

2.5 Outcome Measures

Intraoperative parameters included operative time (minutes) and intraoperative blood loss (mL). Postoperative pain was assessed using the Visual Analogue Scale (VAS; 0–10) at postoperative day 1, 6 weeks, 3 months, and 6 months.

Functional outcomes were evaluated using the Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH) score at 6 weeks, 3 months, and 6 months, with lower scores indicating better functional status. Shoulder range of motion (forward flexion, abduction, and external rotation) was measured using a goniometer at 6 months.

Radiological outcomes included measurement of the Hertel head-shaft angle (HSA) on anteroposterior radiographs **(Figure 10),** with normal values ranging between 130° and 150°, indicating acceptable valgus reduction. Fracture union was assessed using Allman's fracture-healing score **(Table 1),** where Grade 4 indicated complete radiological union. Postoperative complications were recorded throughout the follow-up period.

Figure 10. Measurement of Hertel head–shaft angle (HSA) on anteroposterior shoulder radiograph.

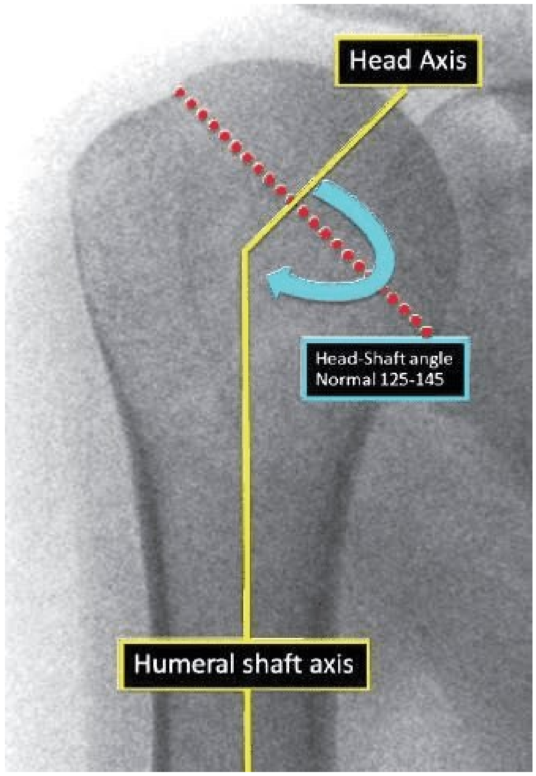


Table 1. Allman's fracture-healing grading system for radiological assessment of fracture union.

Category	Criteria	Score
Periosteal reaction	Full	3
	Moderate	2
	Mild	1
	None	0
Bone union	Union	3
	Moderate bridge (>50%)	2
	Mild bridge (<50%)	1
	Nonunion	0
Remodeling	Full remodeling cortex	2
	Intramedullary canal	1
	No remodeling	0
Maximum total score		**8**

3. RESULTS

3.1 Baseline Characteristics

Sixty patients were enrolled and randomized (DP: n = 30; DS: n = 30). Both groups were comparable at baseline across all demographic and clinical variables (Tables 2–7). The age distribution is detailed in Table 2 and illustrated in Figure 11. The mean age was 56.17 ± 5.63 years in the DP group and 53.60 ± 5.35 years in the DS group (p = 0.414).

Gender distribution (Table 3; Figure 12) showed male predominance in the DP group (60.0%), while the DS group demonstrated equal sex distribution (p = 0.645). The side of involvement (Table 4; Figure 13) showed that the right side was more commonly affected (DP: 70%; DS: 66.7%; p = 0.656). Mechanism of injury (Table 5; Figure 14) revealed that falls were the predominant cause (DP: 70%; DS: 80%; p = 0.232). Neer fracture type distribution (Table 6; Figure 15) was identical in both groups, with 60% Type II and 40% Type III fractures (p = 1.00). The mean injury-to-surgery interval (Table 7; Figure 16) was 3.3 ± 0.92 days in the DP group and 3.0 ± 0.79 days in the DS group (p = 0.215).

Table 2. Age Distribution of Study Participants

Age (years)	Group DP (n=30)	Group DS (n=30)	p value

31–45 years	2 (6.7%)	0 (0%)	0.0843
45–60 years	25 (83.3%)	19 (63.3%)	
>60 years	3 (10.0%)	8 (26.7%)	
Mean ± SD (years)	56.17 ± 5.63	53.60 ± 5.35	0.414

DP = deltopectoral; DS = deltoid-splitting; SD = standard deviation.

Figure 11: Age distribution

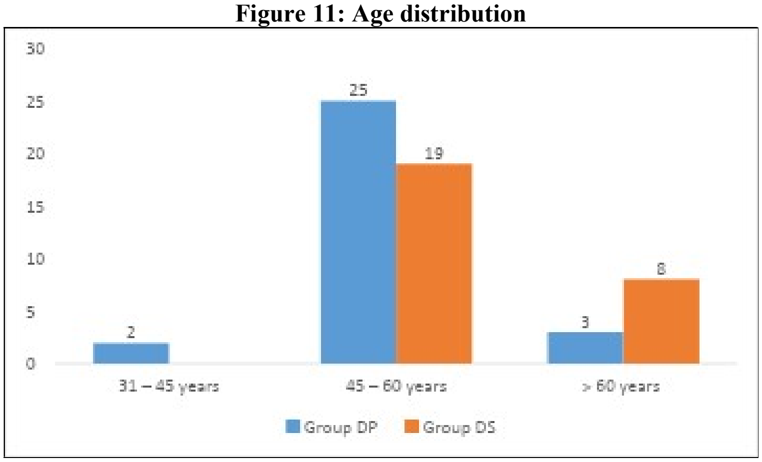


Table 3. Gender Distribution of Study Participants

Gender	Group DP (n=30)	Group DS (n=30)	p value
Male	18 (60.0%)	15 (50.0%)	0.645
Female	12 (40.0%)	15 (50.0%)	

DP = deltopectoral; DS = deltoid-splitting. Chi-squared test. No statistically significant difference in gender distribution was observed between the two groups (p = 0.645).

Figure 12: Gender distribution

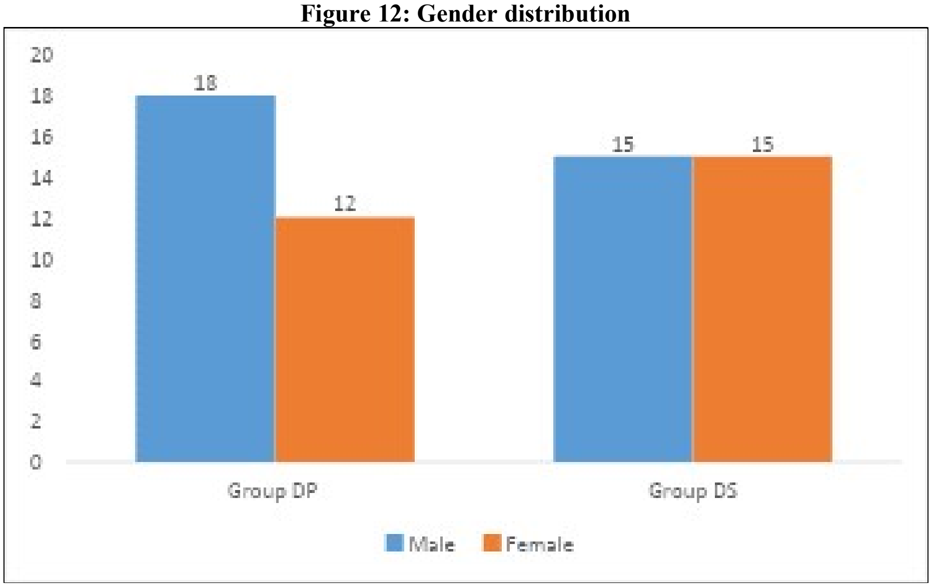


Table 4. Side Involved in Proximal Humerus Fractures

Side Involved	Group DP (n=30)	Group DS (n=30)	p value

Right	21 (70.0%)	20 (66.7%)	0.656
Left	9 (30.0%)	10 (33.3%)	

DP = deltopectoral; DS = deltoid-splitting. Chi-squared test. No statistically significant difference in the side of fracture involvement was observed between the two groups (p = 0.656).

Figure 13: Side of fracture

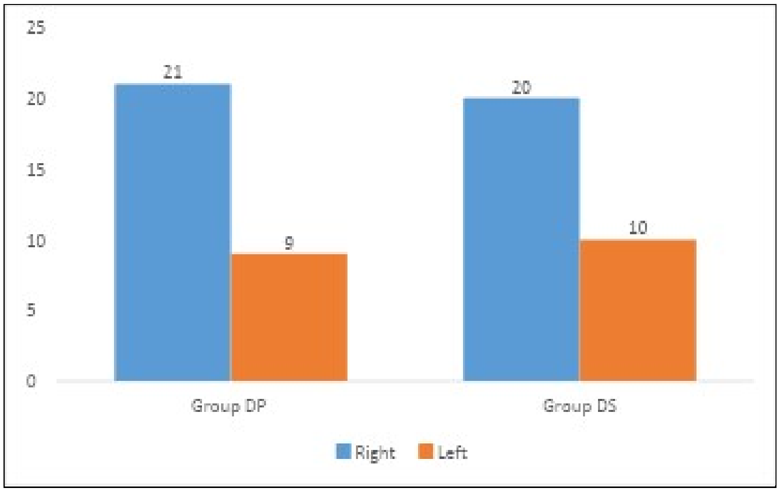


Table 5. Mechanism of Injury in Study Participants

Mechanism	Group DP (n=30)	Group DS (n=30)	p value
Fall	21 (70.0%)	24 (80.0%)	0.232
Road traffic accident	9 (30.0%)	6 (20.0%)	

DP = deltopectoral; DS = deltoid-splitting. Chi-squared test. Falls constituted the predominant mechanism of injury in both groups. No statistically significant difference in injury mechanism was observed between the two groups (p = 0.232).

Figure 14: Mechanism of injury

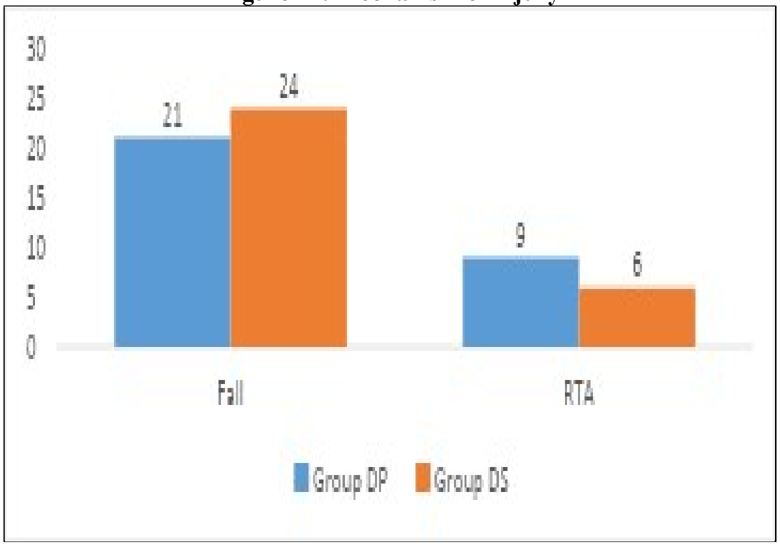


Table 6. Neer Fracture Type Distribution

Neer Fracture Type	Group DP (n=30)	Group DS (n=30)	p value

Type II	18 (60.0%)	18 (60.0%)	1.00
Type III	12 (40.0%)	12 (40.0%)	

DP = deltopectoral; DS = deltoid-splitting. Chi-squared test. An identical distribution of Neer type II and III fractures was observed between the two groups, confirming baseline equivalence (p = 1.00).

Figure 15: Neer fracture types

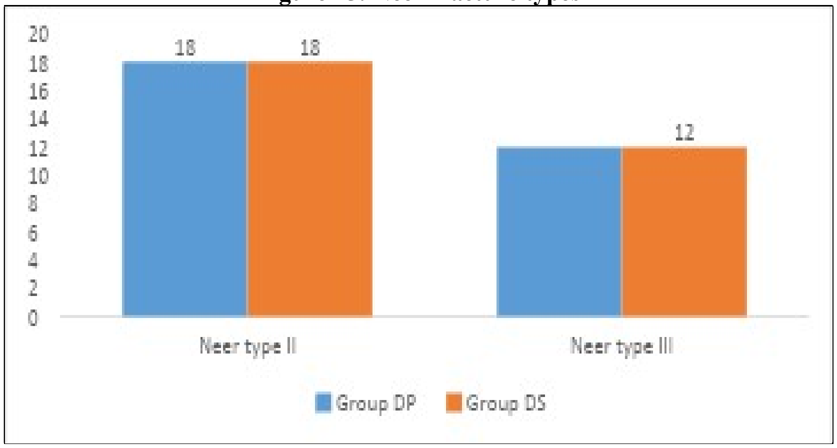
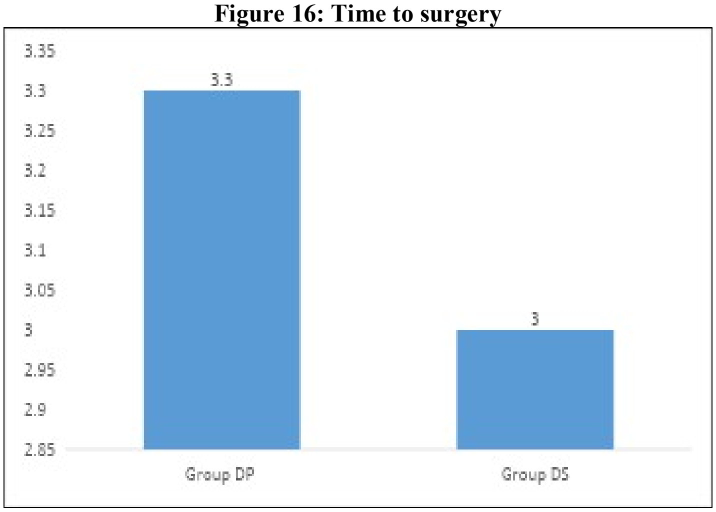


Table 7. Time from Injury to Surgery

Parameter	Group DP (n=30)	Group DS (n=30)	p value
Mean ± SD (days)	3.3 ± 0.92	3.0 ± 0.79	0.215

DP = deltopectoral; DS = deltoid-splitting; SD = standard deviation. Independent samples t-test. No statistically significant difference in the injury-to-surgery interval was observed between the two groups (p = 0.215).

Figure 16: Time to surgery



3.2 Intraoperative Parameters

The DS approach was associated with significantly shorter operative time and lower intraoperative blood loss compared to the DP approach, as shown in Table 8. The mean operative time was 85.20 ± 5.73 minutes in the DS group versus 101.77 ± 8.07 minutes in the DP group (p < 0.001). Mean blood loss was 158.00 ± 14.24 mL in the DS group compared to 224.83 ± 28.15 mL in the DP group (p < 0.001). One patient (3.3%) in the DP group required blood transfusion, whereas none in the DS group did (p = 0.317).

Table 8. Intraoperative Parameters

Parameter	Group DP (n=30)	Group DS (n=30)	p value

Operative time (min), mean ± SD	101.77 ± 8.07	85.20 ± 5.73	<0.001*
Blood loss (mL), mean ± SD	224.83 ± 28.15	158.00 ± 14.24	<0.001*
Blood transfusion, n (%)	1 (3.3%)	0 (0%)	0.317

** Statistically significant (p<0.05).*

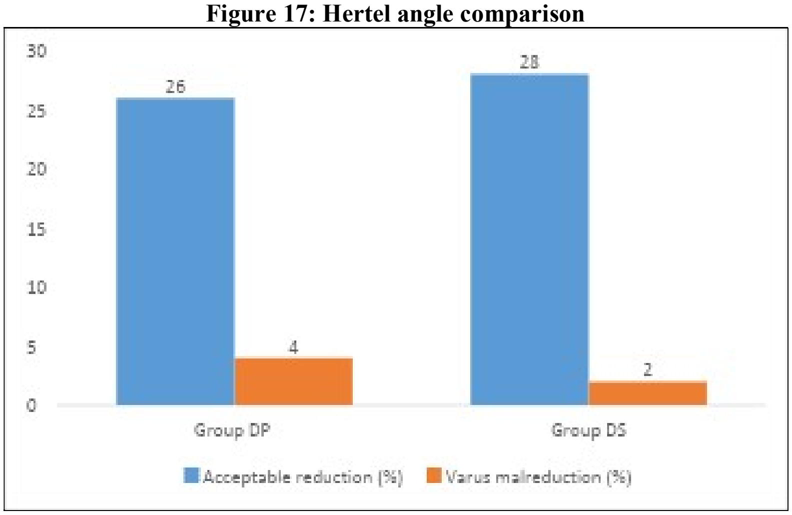
3.3 Radiological Reduction Quality

Radiological assessment using the Hertel method (Table 9; Figure 17) demonstrated a significantly higher mean head–shaft angle in the DS group (136.50° ± 7.24) compared to the DP group (131.97° ± 6.79; p = 0.015). Acceptable reduction was achieved in 93.3% of patients in the DS group and 86.7% in the DP group. Varus malreduction occurred in 13.3% of patients in the DP group and 6.7% in the DS group (p = 0.393).

Table 9. Radiological Reduction Outcomes (Hertel Method)

Parameter	Group DP (n=30)	Group DS (n=30)	p value
Mean head–shaft angle (°)	131.97 ± 6.79	136.50 ± 7.24	0.015*
Acceptable reduction, n (%)	26 (86.7%)	28 (93.3%)	0.393
Varus malreduction, n (%)	4 (13.3%)	2 (6.7%)	0.393

Figure 17: Hertel angle comparison



** Statistically significant (p<0.05).*

3.4 Functional Outcomes (Q-DASH Score)

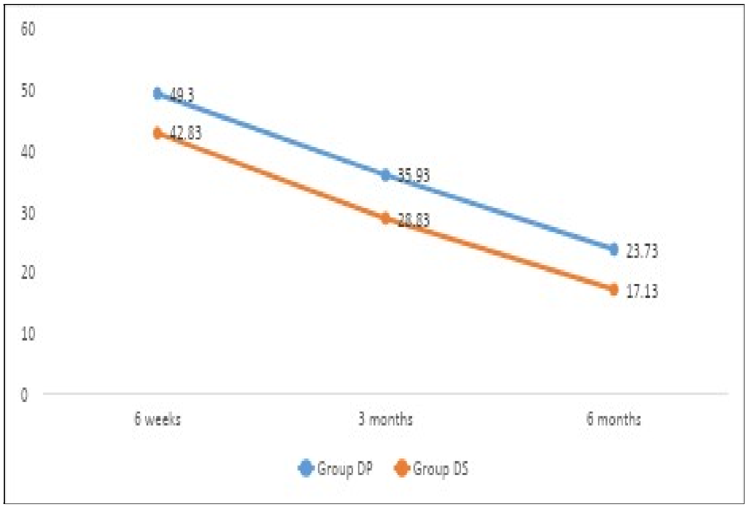
Functional outcomes assessed using the Q-DASH score (Table 10; Figure 18) demonstrated consistently superior recovery in the DS group at all follow-up intervals.

At 6 weeks, mean Q-DASH scores were 42.83 ± 2.96 (DS) and 49.30 ± 3.76 (DP; p < 0.001). At 3 months, scores were 28.83 ± 2.96 (DS) and 35.93 ± 3.68 (DP; p < 0.001). At 6 months, scores were 17.13 ± 2.61 (DS) and 23.73 ± 3.69 (DP; p < 0.001). Lower scores indicate better functional outcome.

Table 10. Q-DASH Scores at Follow-up Intervals

Follow-up	Group DP (n=30)	Group DS (n=30)	p value
6 weeks	49.30 ± 3.76	42.83 ± 2.96	<0.001*
3 months	35.93 ± 3.68	28.83 ± 2.96	<0.001*
6 months	23.73 ± 3.69	17.13 ± 2.61	<0.001*

Figure 18: Q-DASH scores over time



** Statistically significant (p<0.05). Lower Q-DASH = better function.*

3.5 Postoperative Pain (VAS)

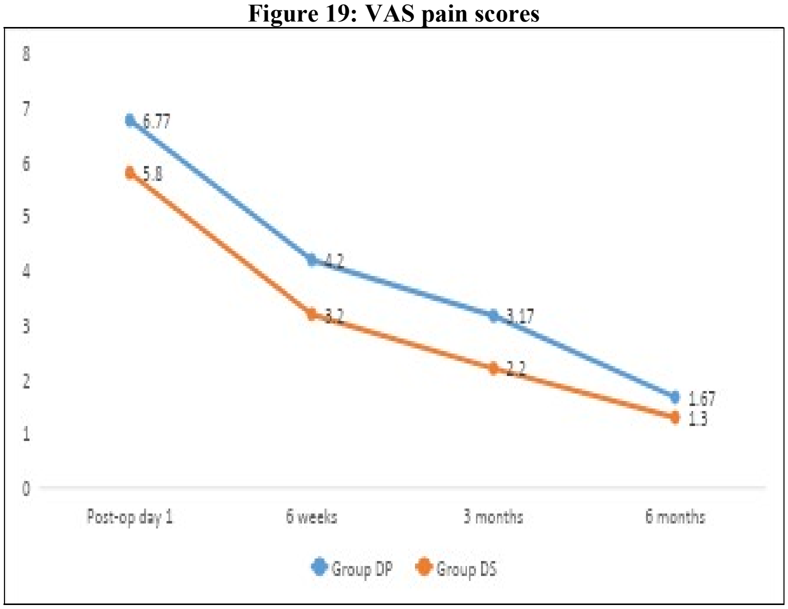
Postoperative pain assessed using the Visual Analogue Scale (VAS) (Table 11; Figure 19) was significantly lower in the DS group at all time points.

At postoperative day 1, VAS scores were 5.80 ± 0.61 (DS) versus 6.77 ± 0.77 (DP; $p < 0.001$). At 6 weeks, scores were 3.20 ± 0.61 (DS) and 4.20 ± 0.61 (DP; $p < 0.001$). At 3 months, scores were 2.20 ± 0.61 (DS) and 3.17 ± 0.59 (DP; $p < 0.001$). At 6 months, scores were 1.30 ± 0.47 (DS) and 1.67 ± 0.66 (DP; $p = 0.016$).

Table 11. VAS Pain Scores at Follow-up

Time Point	Group DP (n=30)	Group DS (n=30)	p value
Postoperative day 1	6.77 ± 0.77	5.80 ± 0.61	<0.001*
6 weeks	4.20 ± 0.61	3.20 ± 0.61	<0.001*
3 months	3.17 ± 0.59	2.20 ± 0.61	<0.001*
6 months	1.67 ± 0.66	1.30 ± 0.47	0.016*

Figure 19: VAS pain scores



** Statistically significant (p<0.05). VAS = Visual Analogue Scale (0–10).*

3.6 Range of Motion at 6 Months

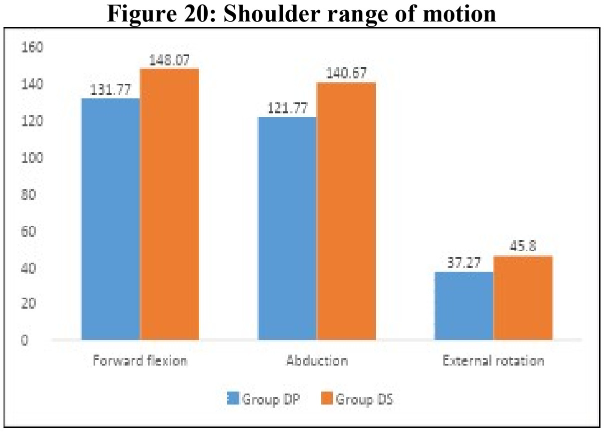
At 6-month follow-up, the DS group demonstrated significantly greater shoulder range of motion across all parameters (Table 12; Figure 20).

Forward flexion was 148.07° ± 6.14 in the DS group compared to 131.77° ± 9.10 in the DP group ($p < 0.001$). Abduction was 140.67° ± 6.34 versus 121.77° ± 9.10 ($p < 0.001$), and external rotation was 45.80° ± 3.69 versus 37.27° ± 4.31 ($p < 0.001$).

Table 12. Range of Motion at 6-Month Follow-up

ROM Parameter	Group DP (n=30)	Group DS (n=30)	p value
Forward flexion (°)	131.77 ± 9.10	148.07 ± 6.14	<0.001*
Abduction (°)	121.77 ± 9.10	140.67 ± 6.34	<0.001*
External rotation (°)	37.27 ± 4.31	45.80 ± 3.69	<0.001*

Figure 20: Shoulder range of motion



** Statistically significant (p<0.05). ROM = range of motion.*

3.7 Fracture Healing (Allman's Score)

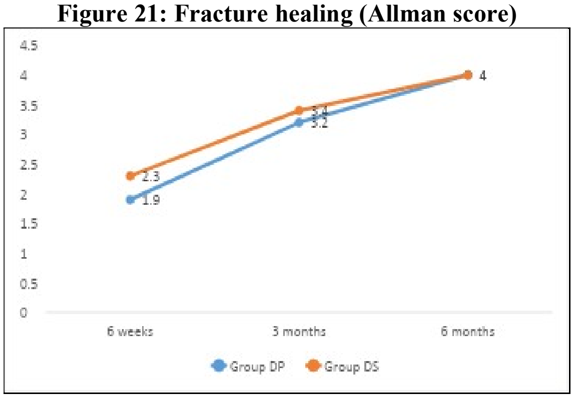
Fracture healing assessed using Allman's score (Table 13; Figure 21) demonstrated significantly faster early union in the DS group.

At 6 weeks, scores were 2.30 ± 0.47 (DS) and 1.90 ± 0.55 (DP; $p = 0.003$). At 3 months, scores were higher in the DS group (3.40 ± 0.50 vs 3.20 ± 0.41), although the difference was not statistically significant ($p = 0.094$). By 6 months, complete radiological union (score 4.0) was achieved in all patients in both groups.

Table 13. Fracture Healing Assessed by Allman's Score

Follow-up	Group DP (n=30)	Group DS (n=30)	p value
6 weeks	1.90 ± 0.55	2.30 ± 0.47	0.003*
3 months	3.20 ± 0.41	3.40 ± 0.50	0.094
6 months	4.00 ± 0.00	4.00 ± 0.00	—

Figure 21: Fracture healing (Allman score)



** Statistically significant (p<0.05). Score 4 = complete union.*

3.8 Postoperative Complications

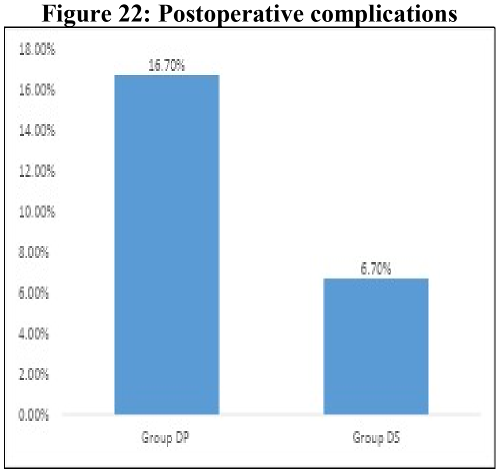
Postoperative complications were more frequent in the DP group compared to the DS group, as summarized in Table 14 and illustrated in Figure 22.

In the DP group, complications included superficial infection (n = 1), screw penetration (n = 1), varus collapse (n = 1), and shoulder stiffness (n = 2), with an overall complication rate of 16.7%. In the DS group, only shoulder stiffness was observed (n = 2), with a total complication rate of 6.7%. No cases of avascular necrosis were observed in either group.

Table 14. Postoperative Complications

Complication	Group DP (n=30)	Group DS (n=30)
Superficial infection	1 (3.3%)	0 (0%)
Screw penetration	1 (3.3%)	0 (0%)
Varus collapse	1 (3.3%)	0 (0%)
Shoulder stiffness	2 (6.7%)	2 (6.7%)
Avascular necrosis	0 (0%)	0 (0%)
Total	5 (16.7%)	2 (6.7%)

Figure 22: Postoperative complications



3.9 Representative Clinical Cases

Representative cases from both study groups are presented to illustrate radiological and functional outcomes following ORIF with PHILOS plating using the deltoid-splitting and deltopectoral approaches.

In the deltoid-splitting group, a patient with a Neer 2-part proximal humerus fracture demonstrated satisfactory fracture union and near-normal shoulder range of motion at 6 months (Figure 23A–C).

In the deltopectoral group, a patient with a Neer 3-part proximal humerus fracture showed radiological union with comparatively lower functional recovery at 6 months (Figure 24A–C).

Figure 23: Case 1 (DS approach outcomes)

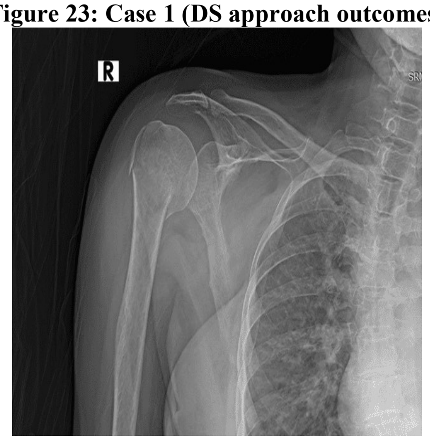


Figure 23A

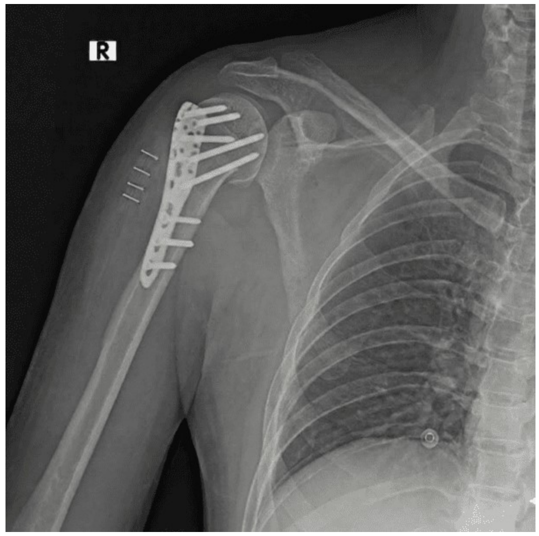


Figure 23B

Figure 23C

Figure 24: Case 2 (DP approach outcomes)

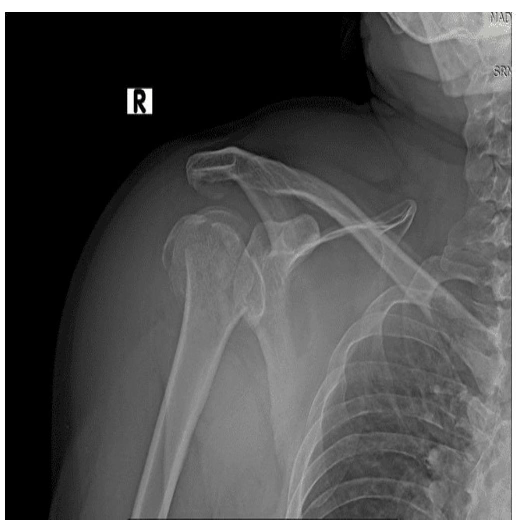


Figure 24A

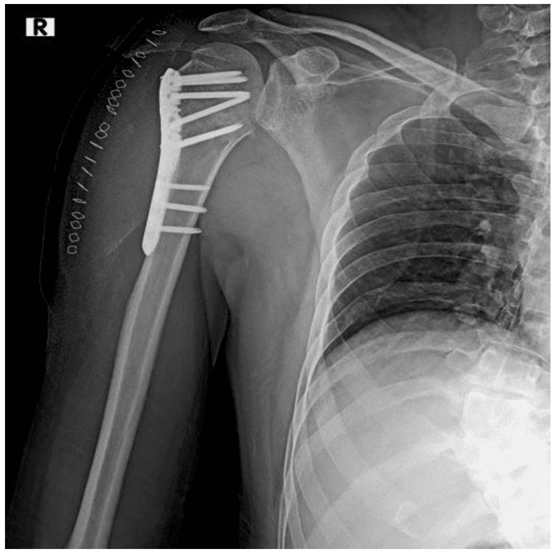


Figure 24B

Figure 24c

4. DISCUSSION

The present prospective randomized comparative study evaluated the influence of surgical approach on outcomes following PHILOS plate fixation for displaced Neer type II and III proximal humerus fractures. The most important finding was that although both the deltopectoral (DP) and deltoid-splitting (DS) approaches achieved complete fracture union and satisfactory radiological outcomes, the DS approach demonstrated significant advantages with respect to operative efficiency, fracture reduction quality, postoperative pain, functional recovery, shoulder range of motion, and complication profile. Specifically, the DS group exhibited significantly shorter operative time (85.20 ± 5.73 vs 101.77 ± 8.07 minutes; $p<0.001$), lower blood loss (158.00 ± 14.24 vs 224.83 ± 28.15 mL; $p<0.001$), superior head–shaft angle restoration (136.50° ± 7.24 vs 131.97° ± 6.79; $p=0.015$), and significantly better Q-DASH scores at all follow-up intervals.

4.1 Intraoperative Parameters

Operative duration and intraoperative blood loss are important indicators of surgical invasiveness and technical efficiency. In the present study, the DS approach reduced operative time by approximately 16.6 minutes and blood loss by approximately 66.8 mL compared with the DP approach. These findings suggest that the direct lateral exposure provided by the DS approach allows easier fracture visualization and implant positioning while minimizing soft-tissue dissection.

Rungchamrussopa et al.[11] conducted a prospective randomized comparison of DP and DS approaches and reported that both techniques were effective and safe for PHILOS fixation. However, the authors observed advantages related to the minimally invasive nature of the DS approach. Similarly, the meta-analysis by Yufeng et al.[12] concluded that the DS approach was associated with superior intraoperative efficiency, reduced blood loss, and earlier postoperative recovery. Zhe et al.[13] and Kishore et al.[14] also reported favorable operative outcomes with the DS approach, attributing these findings to the direct lateral access obtained through the deltoid raphe and the avoidance of extensive soft-tissue stripping.

From a surgical perspective, the DP approach requires identification of the deltopectoral interval, mobilization of the cephalic vein, and significant soft-tissue retraction to access the lateral proximal humerus. In contrast, the DS approach provides a shorter working distance to the fracture site and facilitates direct plate application. Reduced operative duration is particularly beneficial in elderly osteoporotic patients because prolonged anesthesia is associated with increased perioperative morbidity.

4.2 Radiological Reduction Quality and Fracture Alignment

Restoration of proximal humeral anatomy is a critical determinant of successful fixation. In the present study, the mean postoperative head–shaft angle was significantly greater in the DS group than in the DP group (136.50° ± 7.24 vs 131.97° ± 6.79; $p=0.015$). Acceptable reduction was achieved in 93.3% of patients in the DS group compared with 86.7% in the DP group, while varus malreduction occurred less frequently in the DS group (6.7% vs 13.3%).

These findings are clinically relevant because maintenance of the head–shaft angle is closely related to restoration of medial calcar support. Gardner et al.[15] emphasized that inadequate medial support is one of the principal causes of secondary varus collapse following locking plate fixation. Loss of medial column integrity increases cantilever forces across the humeral head and predisposes to screw cut-out, implant failure, and loss of reduction.

Hertel et al.[16] further demonstrated that disruption of the medial hinge and compromised vascularity are important predictors of humeral head ischemia and poor clinical outcomes. Consequently, preservation of fracture biology and restoration of anatomical alignment remain essential goals of fixation.

Sirisreetreerux et al.[17] reported that the DS approach permits direct visualization of the lateral proximal humerus and tuberosity fragments, facilitating anatomical reduction while minimizing periosteal stripping. Lin et al.[18] similarly demonstrated that biologically friendly fixation strategies preserving soft-tissue attachments and local vascularity improve reduction quality and fracture healing.

The significantly greater head–shaft angle achieved in the DS group in the present study likely contributed to the superior functional outcomes observed during follow-up. By maintaining physiological alignment and reducing the risk of varus collapse, the DS approach may provide a more favorable biomechanical environment for fracture healing.

4.3 Functional Outcomes

Functional recovery following proximal humerus fracture fixation depends on fracture stability, soft-tissue preservation, pain control, and rehabilitation. In the present study, functional outcomes assessed using the Q-DASH score consistently favored the DS approach. At six weeks, mean Q-DASH scores were 42.83 ± 2.96 in the DS group and 49.30 ± 3.76 in the DP group. At three months, scores improved to 28.83 ± 2.96 and 35.93 ± 3.68, respectively. By six months, mean Q-DASH scores were 17.13 ± 2.61 in the DS group compared with 23.73 ± 3.69 in the DP group (all $p<0.001$).

The DS group therefore demonstrated a reduction in disability of approximately 60% between six weeks and six months, reflecting substantial functional recovery. These findings are consistent with those reported by Rungchamrussopa et al.[11] and Yufeng et al.,[12] who observed superior early functional outcomes following the DS approach. Similar observations were reported by Zhe et al.[13] and Kishore et al.,[14] who demonstrated favorable shoulder function and earlier return to activities following DS fixation.

The superior functional outcomes observed in the present study may be explained by reduced deltoid trauma, preservation of fracture biology, lower postoperative pain, and earlier mobilization. Because the DS approach avoids extensive anterior soft-tissue dissection, it may better preserve muscle function and facilitate more aggressive rehabilitation.

4.4 Postoperative Pain

Postoperative pain is an important determinant of patient satisfaction and rehabilitation compliance. In the present study, pain scores were consistently lower in the DS group throughout follow-up. Reduced pain likely reflects less extensive soft-tissue dissection and preservation of muscular attachments around the shoulder.

Lin et al.[18] demonstrated that minimally invasive fixation techniques are associated with reduced postoperative pain and earlier mobilization compared with conventional open procedures. Reduced pain not only improves patient comfort but also promotes participation in physiotherapy and reduces the risk of postoperative stiffness.

The lower pain levels observed in the DS group likely contributed to the superior Q-DASH scores and greater shoulder mobility achieved during follow-up.

4.5 Fracture Healing

Early fracture healing was superior in the DS group, as reflected by significantly higher Allman's scores at six weeks. However, by six months all fractures in both groups had achieved complete radiological union.

Suman et al.[19] reported excellent union rates following ORIF of proximal humerus fractures when stable reduction and fixation were achieved. Similarly, Oldrini et al., in a systematic review and meta-analysis of PHILOS plating, concluded that locking plate fixation provides predictable fracture union and satisfactory clinical outcomes across a broad spectrum of fracture patterns.[20]

The improved early healing observed in the DS group may be explained by preservation of periosteal circulation and reduced disruption of fracture hematoma. Nevertheless, the universal union achieved in both groups confirms that both approaches can provide stable fixation when appropriate surgical principles are followed.

4.6 Complications

The overall complication rate was lower in the DS group than in the DP group (6.7% vs 16.7%). Importantly, no cases of avascular necrosis were encountered during the study period.

Agrawal et al.[21] identified screw penetration, varus collapse, shoulder stiffness, infection, and fixation failure as the most common complications associated with PHILOS plating. The low complication rates observed in the present study compare favorably with these reports and likely reflect careful patient selection, meticulous reduction, and stable fixation.

Although arthroplasty remains a treatment option for complex fracture patterns, Rouleau et al.[22] demonstrated that satisfactory outcomes can be achieved following hemiarthroplasty only in selected patients. In contrast, all fractures in the present study were successfully reconstructed and united following PHILOS fixation, preserving the native humeral head and shoulder biomechanics.

The systematic review by Cicio et al.[23] concluded that both DP and DS approaches are effective for proximal humerus fracture fixation, although the DS approach may offer advantages related to soft-tissue preservation and early recovery. Bhayana et al.[24] similarly reported favorable outcomes with both techniques and highlighted the potential benefits of the DS approach in selected fracture patterns.

One of the principal concerns regarding the DS approach is the risk of axillary nerve injury. Dang et al.[25] highlighted the vulnerability of the axillary nerve during proximal humeral fixation and emphasized the importance of meticulous surgical technique. Nevertheless, no axillary nerve injuries were encountered in the present study. Mouraria et al.[26] similarly concluded that anterolateral approaches can be safely performed provided anatomical landmarks are respected and appropriate precautions are taken.

4.7 Clinical Implications

The Cochrane review by Handoll et al.[27] emphasized the need for high-quality comparative studies evaluating the management of proximal humerus fractures. The present prospective randomized study contributes important evidence by directly comparing two commonly employed surgical approaches while simultaneously evaluating radiological, functional, and complication outcomes.

The AO Surgery Reference recommends careful protection of the axillary nerve and preservation of soft tissues when utilizing lateral approaches to the proximal humerus.[28] The absence of nerve injury and the superior clinical outcomes observed in the present study support these recommendations.

Overall, the findings of this study indicate that although both DP and DS approaches achieve reliable fracture union and satisfactory long-term outcomes, the deltoid-splitting approach provides superior operative efficiency, better restoration of proximal humeral anatomy, lower postoperative pain, faster functional recovery, improved shoulder mobility, and a lower complication rate. Therefore, for displaced Neer type II and III proximal humerus fractures treated with PHILOS plating, the deltoid-splitting approach appears to offer meaningful clinical and biomechanical advantages over the conventional deltopectoral approach.

4.8 Limitations

Several limitations warrant acknowledgement. The 6-month follow-up duration precludes evaluation of late complications and long-term functional trajectories. The single-centre design may limit generalizability. Convenience-based allocation, rather than a formally concealed randomization sequence, introduces the possibility of selection bias. The study did not assess shoulder-specific patient-reported outcome measures (e.g., Oxford Shoulder Score, Constant–Murley Score), axillary nerve function in the DS group, or advanced radiological parameters. Surgeon-experience variation was not formally controlled. Future multicentre randomized trials with extended follow-up, standardized outcome sets, and CONSORT-compliant methodology are warranted.

5. CONCLUSION

This prospective randomized study demonstrates that both deltopectoral and deltoid-splitting approaches for PHILOS plate fixation of Neer type II and III proximal humerus fractures are safe and reliably achieve complete radiological union. However, the deltoid-splitting approach confers significant advantages across multiple clinically relevant domains: shorter operative time, reduced intraoperative blood loss, superior fracture alignment, lower postoperative pain at all time points, earlier and greater functional recovery, improved shoulder range of motion at 6 months, and a lower overall complication rate. These findings support preferential use of the deltoid-splitting technique in appropriately selected patients and provide objective comparative data to inform surgical decision-making for this prevalent and functionally important injury

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