Comparative Study

MODIFIED TRANDELTOID APPROACH *VS* THE DELTOPECTORAL APPROACH. A COMPARATIVE STUDY IN FRACTURES OF THE PROXIMAL HUMERUS

O. De Carolis[1], A. Benedetto[2], A. De Felice[1], V. Belviso[1], A. Pulcrano[2] and G. Solarino[2]

[1]Orthopaedic and Traumatology Unit, San Giacomo Hospital, Monopoli (Ba), Italy;
[2]Department of Translational Biomedicine and Neuroscience "DiBraiN", School of Medicine and Surgery, University of Bari, Orthopaedic and Traumatology Unit, AOU General Hospital of Bari, Bari, Italy

Correspondence to:
Andrea De Felice, MD
Orthopaedic and Traumatology Unit,
San Giacomo Hospital,
Largo Veneziani, 21,
70043 Monopoli (Ba), Italy
Email: andrea.defelice@asl.bari.it

ABSTRACT

Proximal humerus fractures often require open reduction and internal fixation using plates and screws. This study compares the deltopectoral approach (DP) and the modified transdeltoid approach (MDS) in 54 patients, evaluating clinical and radiographic outcomes, operative time, and complications. Clinical outcomes, assessed with the Constant-Murley Score and VAS scale, were comparable between the two approaches at 1, 3, and 6 months. Postoperative pain improved progressively, with no significant differences between groups. However, operative time was significantly shorter for the MDS group (65 ± 5 minutes) compared to the DP group (92 ± 4.3 minutes). Complications, such as malunion, avascular necrosis, and screw penetration, were minimal and showed no significant differences between approaches. Importantly, no neurovascular injuries were observed in any patients. In conclusion, DP and MDS approaches are safe and effective for treating proximal humerus fractures. The MDS provides a notable advantage in reduced operative time, making it a valuable alternative, particularly for fractures involving the posterior humerus. The choice of approach should consider fracture type and surgeon experience. Further research is needed to validate these findings.

KEYWORDS: *shoulder, deltoid-splitting approach, proximal humerus fracture, traumatology, deltopectoral approach*

INTRODUCTION

Proximal humerus fractures represent one of the most challenging injuries to manage in skeletal trauma, being the third most common fracture and accounting for approximately 4-10% of all fractures (1). The incidence, ranging between 31 and 250 cases per 100,000 inhabitants per year, steadily increases due to population aging. This type of fracture predominantly affects individuals over 60 years of age, with a female-to-male ratio of 4:1 in older women, often associated with osteoporosis. Conversely, high-energy fractures are more frequent in younger individuals and typically require more complex surgical treatments (2).

The treatment of proximal humerus fractures, particularly those involving the epiphysis or metaepiphysis, commonly relies on open reduction and internal fixation with plates and screws, although in some cases, especially in older patients with lower functional demands, the external fixation (3) or the reverse shoulder arthroplasty can be used

Received: 2 August 2024
Accepted: 15 September 2024

(4). Among the most widely used surgical options is the deltopectoral (DP) approach, which allows for extensive exposure of the anterior and lateral regions of the shoulder. However, this approach requires significant soft tissue dissection and muscle retraction to achieve adequate visualization, increasing the risk of devascularization of fracture fragments, particularly the humeral head. Furthermore, the DP approach does not provide direct visualization of the posterolateral portion of the humeral head, making it challenging to reduce large retracted fragments, such as the greater tuberosity, especially in muscular patients.

An alternative to the DP approach is the deltoid-splitting (DS) approach, which provides 270° exposure of the proximal humerus with less extensive soft tissue dissection. However, the traditional use of the DS approach has been limited by the perceived risk of injury to the anterior branch of the axillary nerve, particularly when distal extension of the split is required for plate placement. To overcome these limitations, a modified transdeltoid (MDS) approach has been developed, combining the advantages of the DS approach with greater safety for the axillary nerve, minimizing excessive retraction and preserving neurovascular integrity.

Classification and preoperative planning play a crucial role in the surgical management of these fractures. Standard radiographic methods are essential for initial assessment, but computed tomography (CT) with 3D reconstruction provides indispensable details for identifying fracture morphology and planning the intervention. Among the most commonly used classifications are the Neer classification (5), based on fragment displacement, and the Hertel classification (6), which integrates anatomical and vascular criteria, offering a more detailed understanding of fractures and their associated risks.

This study aims to compare the clinical and radiographic outcomes of patients undergoing surgical intervention using the MDS and the DP approaches. By analyzing intraoperative parameters, such as surgical time and complications, as well as clinical and radiological follow-ups at 1, 3, and 6 months, this study seeks to evaluate which approach ensures better results in terms of efficacy, safety, and preservation of shoulder function.

MATERIALS AND METHODS

The study included patients treated at the Orthopedics and Traumatology Units of the Policlinico di Bari and San Giacomo Hospital in Monopoli (BA) between November 2022 and March 2024.

Study design and patient selection

A total of 92 patients underwent surgical treatment for proximal humerus fractures with open reduction and internal fixation (ORIF) using PHILOS plates (Synthes Medical). Of these, 20 patients were excluded due to the absence of preoperative CT scans required for radiological classification. The remaining 72 patients had proximal humerus fractures classified as Neer type 3-4 (tuberosity displacement > 5 mm and humeral head angulation > 45°) by an experienced senior musculoskeletal radiologist.

Exclusion criteria included:

- absence of a preoperative CT scan;
- dislocations or open fractures;
- psychiatric disorders;
- associated injuries to the ipsilateral upper limb;
- comorbidities preventing surgery;
- polytrauma cases.

A total of 54 patients met the inclusion criteria and were enrolled after providing informed consent. Patients treated at the San Giacomo Hospital were operated on using the MDS approach, while those treated at the Policlinico di Bari underwent surgery using the DP approach. All surgeries were performed by two senior surgeons (DO and VG) specializing in upper limb trauma.

Study objectives

The primary objective was to evaluate whether one surgical approach provides superior clinical and radiographic outcomes by analyzing follow-up results at 1, 3, and 6 months.

The secondary objectives included:

1. comparing the operative time between the MDS and DP approaches;
2. analyzing postoperative hospital stays to determine differences in recovery time;
3. assessing postoperative pain levels using the Visual Analog Scale (VAS);

4. comparing functional recovery times using standardized scales, including the Constant-Murley Shoulder Score (7) and QuickDASH (8);
5. evaluating the incidence of reoperations in both groups.

Clinical protocol

Postoperative follow-ups were conducted at 1, 3, and 6 months. In some patients, the B-STEP protocol for the follow-up was used (9). The following evaluation tools were used:

- Constant-Murley Shoulder Score to assess shoulder function;
- Quick DASH to evaluate disability;
- VAS to measure pain intensity.

Complications such as infections, instability, and nerve injuries were recorded. Muscle strength in abduction was tested by measuring maximum resistance. Functional outcomes were classified based on the difference in Constant scores between the operated and contralateral shoulder:

- excellent: <11
- good: 11–20
- fair: 21–30
- poor: >30

Radiographic protocol

Radiographic assessments were performed preoperatively and at follow-ups using standard anteroposterior, transthoracic, and CT imaging. Postoperative radiographs evaluated malunion [defined using Beredjiklian criteria (10)] and other complications. Follow-up radiographs included anteroposterior views in neutral, internal, and external rotation.

Rehabilitation protocol

Post-surgery, all patients followed a standardized rehabilitation program. Pendulum exercises were initiated immediately after surgery, followed by supervised progressive range-of-motion and muscle-strengthening exercises, mainly targeting the deltoid muscle. Lifting heavy weights was discouraged during the recovery period. Periodic clinical and radiographic evaluations were conducted at 1, 3, and 6 months.

Statistical analysis

Descriptive statistics were used to summarize patient demographics and clinical data. Mean and standard deviation were calculated for continuous variables. The Student's t-test was used to compare pre- and postoperative outcomes, with a statistical significance of $p<0.05$. Mean values for Constant-Murley, Quick DASH, VAS, and range of motion were rounded to two decimal places.

The results of this integrated protocol provided a comprehensive analysis of the comparative efficacy of the MDS and DP approaches for the surgical treatment of proximal humerus fractures.

DELTOPECTORAL APPROACH

The deltopectoral approach is widely used for open reduction and internal fixation of proximal humerus fractures. The incision, typically 10-12 cm long, extends from the coracoid process toward the humeral insertion of the deltoid, parallel to the deltoid muscle along the deltopectoral groove. The groove can be located by marking the skin to identify the "valley" of the interval. However, this incision crosses Langer's skin tension lines obliquely, potentially resulting in wider scar formation and less favorable cosmetic outcomes.

The richly vascularized subcutaneous adipose tissue can be exposed by retracting the pectoralis major medially and the deltoid laterally. A fat triangle in the proximal part of the dissection, extending obliquely across the incision, identifies the cephalic vein, which should be preserved to minimize postoperative arm edema. Preferably, the dissection is performed medially to the vein, with fewer branches than the lateral side.

The deltoid and pectoralis muscles are bluntly dissected to expose the clavipectoral fascia, which is incised laterally to the conjoint tendon and inferior to the coracoacromial ligament. Subacromial and subdeltoid spaces are carefully opened with adequate hemostasis to prevent excessive bleeding. Care is required to avoid injury to the posterior circumflex humeral artery during subdeltoid dissection. The subacromial bursa must be removed to visualize the rotator cuff adequately.

Visualization of the fracture

Lateral retraction of the deltoid with a modified Hohmann retractor and medial retraction of the conjoint tendon with a Langenbeck retractor allows visualization of the fractured humeral head. Particular attention is needed to protect the musculocutaneous nerve, which enters the coracobrachialis approximately 2.5 cm distal to the coracoid process. Excessive retraction under the conjoint tendon may cause neuropraxia of the nerve.

Abduction of the shoulder facilitates lateral exposure by reducing deltoid tension. Exposure can be improved if needed by partially releasing the deltoid or pectoralis major insertions.

Fracture reduction and fixation

Temporary reduction of the fracture is achieved by placing traction sutures on the osteotendinous junctions of the subscapularis, supraspinatus, and infraspinatus tendons. Kirschner wires may be temporarily used to maintain reduction. Once satisfactory reduction is achieved, the plate is placed along the lateral surface of the proximal humerus, aligned with the humeral shaft and lateral to the bicipital groove, ensuring proper alignment with the greater tuberosity.

This approach provides excellent exposure for managing complex fractures while requiring careful attention to neurovascular structures and the subacromial region.

MODIFIED TRANS-DELTOID APPROACH

The modified transdeltoid approach provides a minimally invasive alternative for open reduction and internal fixation of proximal humerus fractures. An 8 cm incision is made along the palpable anterolateral edge of the acromion, extending distally in line with the deltoid fibers.

Exposure and visualization

Once the proximal fibers of the deltoid muscle are exposed, the anterior, lateral, and posterior portions of the deltoid are identified. The fibrous raphe between the anterior and middle heads is divided along the fibers, creating a proximal window for visualizing the lateral wall of the humerus. The lateral portion of the deltoid displays an oblique orientation, running craniocaudally from posterior to anterior. Blunt dissection along the lateral and posterior heads of the deltoid creates a distal window, allowing visualization of the proximal metadiaphysis of the humerus.

For the proximal window, Hohmann retractors are placed anteriorly and posteriorly to the proximal humeral epiphysis, retracting the anterior and middle heads of the deltoid, respectively. Retractors separate the middle and posterior deltoid heads for the distal window, enabling access to the humeral diaphysis (Fig. 1).

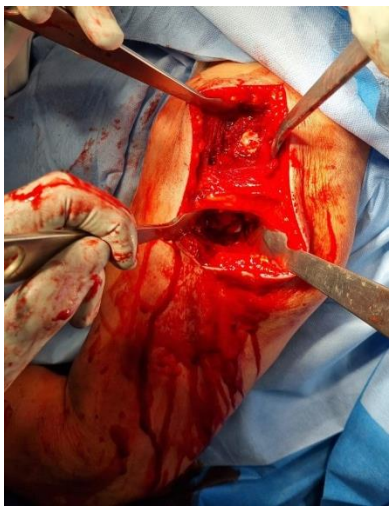

Fig. 1. *Development of the proximal and distal window.*

Fracture reduction and fixation

Through the proximal window, manipulation of the humeral head and reduction of the associated fracture is performed. Traction sutures are placed at the osteotendinous junctions of the subscapularis, supraspinatus, and infraspinatus tendons to reduce multi-part fractures. In cases of cancellous bone loss, artificial bone substitutes may be used.

Temporary Kirschner wires can be inserted to maintain fracture reduction without interfering with plate placement. The plate is slid through the proximal window along the bone plane, deep to the lateral deltoid head, and positioned on the lateral surface of the humerus. Proper alignment along the humeral shaft, the bicipital groove, and the apex of the greater tuberosity is confirmed.

Through the distal window, the reduction of metadiaphyseal fractures or placement of a clamp for humeral neck fracture management is achieved. The distal window also facilitates direct visualization of plate positioning along the humeral axis (Fig. 2).

Fig. 2. *Placement of the plate.*

Neurovascular safety

This approach avoids isolating the neurovascular bundle (NVB), including the anterior branch of the axillary nerve and the posterior circumflex humeral artery. The NVB is protected throughout by the lateral head of the deltoid.

Cranial mobilization of the lateral deltoid head enables the placement of screws in the calcar region of the humerus, providing secure fixation. This approach offers effective exposure for fracture management while minimizing soft tissue dissection and reducing the risk of neurovascular injury.

RESULTS

All 54 patients completed the follow-up at 1, 3, and 6 months, allowing for a comprehensive analysis of demographic, clinical, functional, and surgical outcomes.

Demographic and clinical data

The mean age was comparable between the two groups (65.71 ± 10.29 years for the DP group vs. 65.27 ± 9.59 years for the MDS group, $p = 0.92$), indicating that age did not significantly influence the outcomes. A significant difference was observed in gender distribution ($p = 0.00002$), with a slightly higher percentage of males in the DP group (44.8%) compared to the MDS group (40.7%). However, this difference did not appear to affect the primary clinical outcomes (Table I).

Table I. *Preoperative details of the analyzed samples.*

Patient details	Group DP (n=28)	Group MDS (n=26)	p-value
Age	65.71 ± 10.29	65.27 ± 9.59	0.92
Gender			0.00002
Male (%)	13 (44.8%)	11 (40.7%)	
Female (%)	15 (51.7%)	15 (55.6%)	
Neer's Classification			0.694
3 fragments	51.7%	51.9%	
4 fragments	44.8%	44.4%	
Side			0.00002
Right	55.2%	59.3%	
Left	41.4%	37.0%	
Days between fracture and surgery	3.25 ± 1.43	2.35 ± 1.90	0.052
Comorbidities	1.5	1.7	0.617

Outcomes

Tables II and III report results at 1- and 3-month follow-ups, whereas Table IV reports results at 6-month follow-ups.

Table II. *One-month follow-up.*

Outcome	Group DP	Group MDS	p-value
Relative Constant-Murley Score	22.28 ± 2.23	21.98 ± 2.20	0.8231
Internal Rotation	2.42 ± 0.24	2.48 ± 0.25	0.6784
External Rotation	2.46 ± 0.25	2.51 ± 0.25	0.7712
Strength Recovery (%)	21.33	21.00	N/A
Abduction	2.57 ± 0.26	2.58 ± 0.26	0.9546

Table III. *Three-month follow-up.*

Outcome	Group DP	Group MDS	p-value
Relative Constant-Murley Score	52.00 ± 5.20	51.28 ± 5.13	0.8341
Internal Rotation	5.63 ± 0.56	5.80 ± 0.58	0.6235
External Rotation	5.74 ± 0.57	5.87 ± 0.59	0.7632
Strength Recovery (%)	49.77	49.00	N/A
Abduction	5.99 ± 0.60	6.03 ± 0.60	0.9071

Postoperative complications

Postoperative complications were similar across the two groups. Major complications such as malunion, screw penetration, and avascular necrosis (AVN) showed no statistically significant differences ($p = 1.0$). Notably, no cases of axillary nerve paralysis or stupor were observed, addressing a common concern with the transdeltoid approach. These findings suggest that both techniques carry a low risk of complications.

Operative time

A significant difference was observed in operative time between the two approaches. The DP approach required a mean duration of 92 ± 4.3 minutes, while the MDS approach averaged 65 ± 5 minutes ($p < 0.05$). This demonstrates that the MDS technique is significantly faster without compromising functional or radiographic outcomes.

Pain assessment (VAS)

Pain levels, assessed using the Visual Analog Scale (VAS), showed progressive improvement in both groups over the follow-up period. At 1 month, mean VAS scores were 6.2 ± 0.6 for DP and 6.5 ± 0.7 for MDS ($p = 0.4572$), with no significant difference. By 6 months, pain levels were minimal, with VAS scores of 1.0 ± 0.3 for DP and 1.1 ± 0.4 for MDS ($p = 0.5913$), indicating comparable clinical outcomes in pain control (Table IV).

Table IV. *Final results of the study at 6 months.*

Outcome	Group DP	Group MDS	p-value
Relative Constant-Murley Score (mean ± S.D.)	74.27 ± 8.19	73.26 ± 8.02	0.8227
Degree of Functional Outcome			
	9	11	
Excellent	7	6	
Good	8	7	
Fair	4	2	
Poor	8.05 ± 0.95	8.28 ± 1.23	0.6428
Internal Rotation (mean ± S.D.)	8.2 ± 1.03	8.38 ± 0.9	0.7433
External Rotation (mean ± S.D.)	71.1	70.0	
Strength Recovery (%)	8.55 ± 1.19	8.61 ± 1.03	0.9132
Abduction (mean ± S.D.)			
	1	0	1
Malunion	0	1	1
Screw Penetration	1	1	1
AVN	92 ± 4.3	65 ± 5	significativa

Summary of results

Both the deltopectoral and modified trans-deltoid approaches provided similar functional and radiographic outcomes with low complication rates. The MDS approach demonstrated a significant advantage in operative time, making it a more efficient alternative without compromising patient safety or long-term results. These findings support the efficacy and safety of both techniques while highlighting the time-saving benefit of the MDS approach (Table V, Fig. 3).

Table V. *VAS evaluation.*

Follow-up	DP (mean VAS±SD)	MDS (mean VAS±SD)	p-value
1 month	6.2 ± 0.6	6.5 ± 0.7	0.4572
3 months	3.4 ± 0.5	3.6 ± 0.6	0.6087
6 months	1.0 ± 0.3	1.1 ± 0.4	0.5913

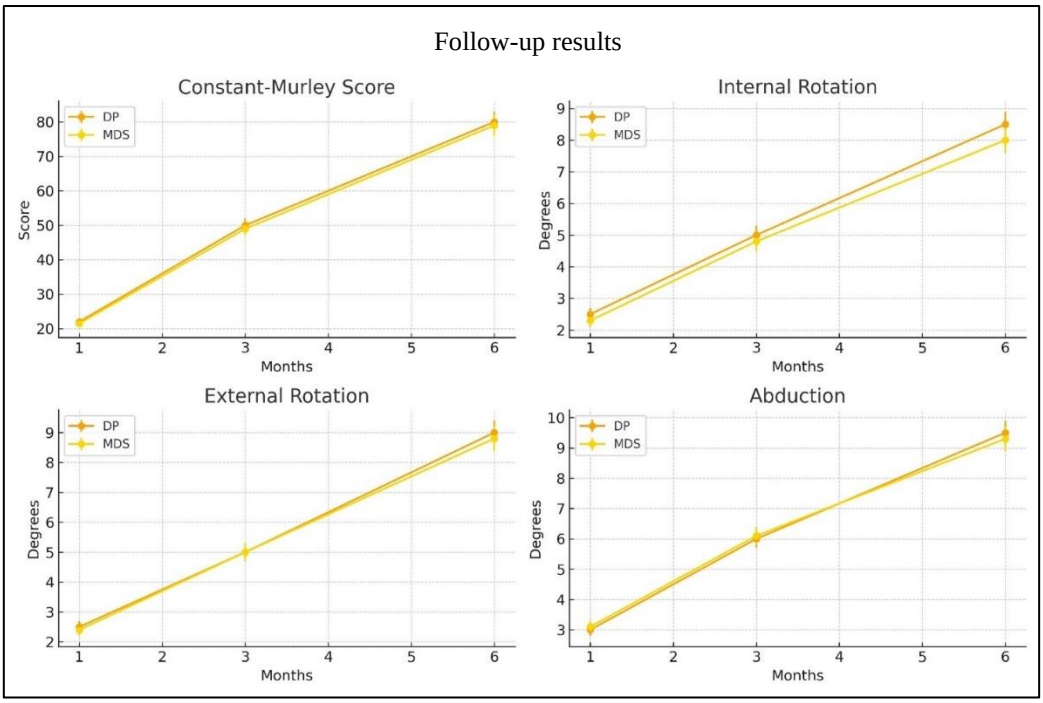

Fig. 3. *Clinical parameters compared.*

DISCUSSION

The DP approach has historically been the most commonly used technique for the treatment of proximal humerus fractures. However, its limited exposure can reduce posterior fragments, particularly the greater tuberosity (GT), which is challenging. In such cases, significant retraction of the deltoid is often required to access the posterolateral region of the proximal humeral epiphysis. The MDS approach was developed to address these limitations as a viable alternative for managing complex fractures.

The MDS approach provides direct exposure to the lateral surface of the humeral head, enabling 270° visualization while minimizing periosteal stripping and facilitating the reduction of the posterior GT fragment. Mobilization of the middle deltoid bundle allows direct access to the fracture lines, and the use of a wide-tipped Cocker clamp permits indirect elevation of the humeral head and temporary fixation with a Kirschner wire in the correct position relative to the glenoid. Hohmann retractors placed between the anterior and middle deltoid heads further assist in the reduction of the tuberosities. The plate is advanced along the lateral cortical surface of the proximal humeral metaphysis without compromising the neurovascular bundle during placement.

One technical issue encountered with the MDS approach is that the holes for the calcar and central screws in the plate are often obscured by the middle deltoid bundle. Mobilizing this bundle allows access to these holes without risking injury to the axillary nerve. Despite these technical peculiarities, our findings demonstrate that the MDS and DP approaches yield comparable functional outcomes and pain relief.

Follow-up data at 1, 3, and 6 months showed similar clinical results between the two groups, as measured by the Constant-Murley Score and the VAS. Both techniques proved to be safe and effective, with a minimal incidence of complications. Cases of malunion and avascular necrosis (AVN) requiring reoperations with reverse shoulder arthroplasty were exclusively observed in patients with four-part fractures, a type already associated with higher complication rates according to Neer's classification.

From a practical standpoint, each approach offers distinct advantages depending on the fracture's location. The DP approach is preferable for anterior fracture-dislocations of the proximal humerus, providing superior visualization of the anterior aspect of the humeral head. Conversely, the MDS approach is better suited for fractures involving the posterior portion of the proximal humerus, enabling direct management of the posterior GT fragment, which is challenging to address with the DP approach.

Further studies are needed to evaluate whether implant removal following the MDS approach may present challenges. The dissection of the axillary nerve through scar tissue could prove difficult, potentially complicating implant removal.

Another critical distinction between the two approaches is operative time. The MDS approach allows for a faster procedure due to direct visualization of the fracture and more intuitive reduction maneuvers, requiring less fluoroscopy. This reduction in operative time may translate into lower surgical stress and reduced patient anesthesia duration (Fig. 4).

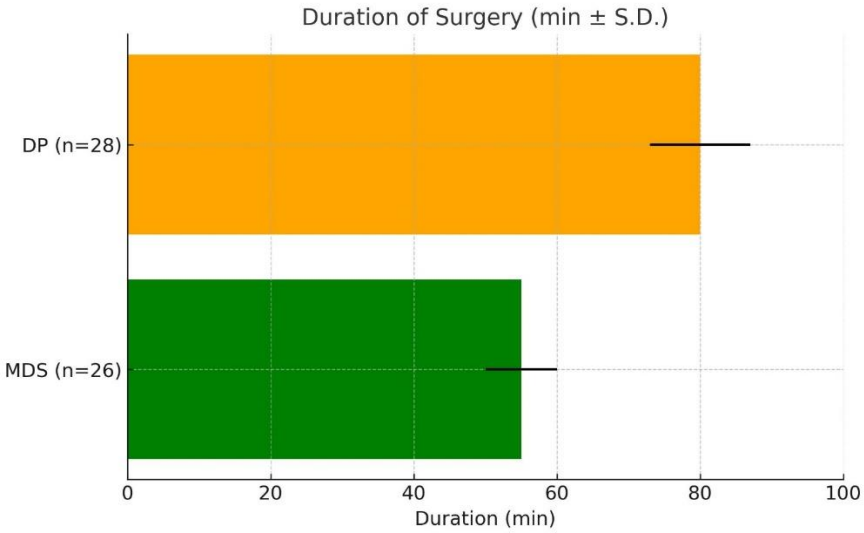

Fig. 4. *Intervention duration compared.*

Despite the strengths of our study, its retrospective design and relatively small sample size represent limitations. Nonetheless, it includes patients with complex four-part fractures as per Neer's classification, documenting the effectiveness of plate and screw fixation for these challenging injuries when performed by experienced surgeons.

In conclusion, both approaches are valid options for the surgical treatment of proximal humerus fractures. The choice of surgical approach, type of fixation, or materials (11) should be tailored to the specific fracture configuration and the surgeon's expertise. The MDS approach provides distinct advantages for posterior fractures and offers significant time efficiency without compromising safety or clinical outcomes.

REFERENCES

1. Court-Brown CM, Garg A, McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthopaedica Scandinavica*. 2001;72(4):365-371. doi:https://doi.org/10.1080/000164701753542023
2. Iglesias-Rodríguez S, Domínguez-Prado DM, García-Reza A, et al. Epidemiology of proximal humerus fractures. *Journal of Orthopaedic Surgery and Research*. 2021;16(1). doi:https://doi.org/10.1186/s13018-021-02551-x
3. Vicenti G, Antonella A, Filipponi M, et al. A comparative retrospective study of locking plate fixation versus a dedicated external fixator of 3- and 4-part proximal humerus fractures: Results after 5 years. *Injury*. 2019;50:S80-S88. doi:https://doi.org/10.1016/j.injury.2019.01.051
4. Maccagnano G, Solarino G, Pesce V, et al. Plate *vs* reverse shoulder arthroplasty for proximal humeral fractures: The psychological health influence the choice of device?. *World Journal of Orthopedics*. 2022;13(3):297-306. doi:https://doi.org/10.5312/wjo.v13.i3.297
5. Neer Cs nd. Displaced proximal humeral fractures. Part I. Classification and evaluation. By Charles S. Neer, I, 1970. *JBJS*. 1987;52(223):3-10.
6. Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular proximal humerus fracture. *Journal of Shoulder and Elbow Surgery*. 2004;13(4):427-433. doi:https://doi.org/10.1016/j.jse.2004.01.034
7. Vrotsou K, Ávila M, Machón M, et al. Constant–Murley Score: a systematic review and standardized evaluation in different shoulder pathologies. *Quality of Life Research*. 2018;27(9):2217-2226. doi:https://doi.org/10.1007/s11136-018-1875-7
8. Angst F, Schwyzer HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and Its Short Version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society Standardized Shoulder. *Arthritis Care & Research*. 2011;63(S11):S174-S188. doi:https://doi.org/10.1002/acr.20630
9. Moretti L, Bizzoca D, Farì G, et al. Bari Shoulder Telemedicine Examination Protocol (B-STEP): A Standard Protocol for Personalized Remote Shoulder Examination. *Journal of Personalized Medicine*. 2023;13(7):1159-1159.

doi:https://doi.org/10.3390/jpm13071159

10. Beredjiklian PK, Hotchkiss RN, Athanasian EA, Ramsey ML, Katz MA. Recalcitrant Nonunion of the Distal Humerus. *Clinical orthopaedics and related research*. 2005;&NA;(435):134-139. doi:https://doi.org/10.1097/01.blo.0000157928.20381.46
11. Ceddia M, Solarino G, Tucci M, Lamberti L, Trentadue B. Stress Analysis of Tibial Bone Using Three Different Materials for Bone Fixation Plates. *Journal of Composites Science*. 2024;8(9):334-334. doi:https://doi.org/10.3390/jcs8090334