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FUNCTIONAL OUTCOME OF VOLAR LOCKING PLATE FIXATION IN ADULTS FOR DISPLACED INTRA ARTICULAR FRACTURE OF DISTAL RADIUS

Original Research

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ABSTRACT

Background: Distal radius fractures are among the most frequently encountered orthopedic injuries, particularly affecting children, adolescents, and elderly individuals due to falls on an outstretched hand (FOOSH). These fractures can severely impair wrist function and require timely and effective intervention. Volar locking plate fixation has emerged as a preferred surgical technique for managing displaced intra-articular fractures due to its superior biomechanical stability and ability to maintain fracture reduction. Despite its widespread use, limited local data exists on functional outcomes, especially in adult populations.

Objective: To evaluate the functional outcomes of volar locking plate fixation in adult patients with displaced intra-articular distal radius fractures using the Disabilities of the Arm, Shoulder, and Hand (DASH) score.

Methods: This prospective descriptive study was conducted over a six-month period at the Orthopedic Department of Combined Military Hospital, Peshawar. A total of 97 adult patients aged between 18 and 70 years with radiologically confirmed displaced intra-articular distal radius fractures were included using non-probability consecutive sampling. Patients with open fractures, ipsilateral upper limb involvement, or pre-existing deformities were excluded. All patients underwent fixation with a volar locking plate under general anesthesia. Functional recovery was assessed at 10 weeks postoperatively using the DASH questionnaire. Data were analyzed using SPSS version 21, with descriptive and inferential statistics applied, including stratification by age, gender, socioeconomic status, and BMI.

Results: The mean DASH score was 28.6 ± 8.3. A total of 45 patients (46.4%) had excellent outcomes, 30 (30.9%) had good outcomes, 15 (15.5%) had fair outcomes, and 7 (7.2%) had poor outcomes. Younger age and higher socioeconomic status were significantly associated with better outcomes. Minor complications included transient median nerve irritation in 5 patients (5.2%), superficial infections in 3 (3.1%), and plate loosening in 1 patient (1.0%).

Conclusion: Volar locking plate fixation is a safe and effective treatment for displaced intra-articular distal radius fractures in adults, offering favorable functional outcomes and low complication rates. Tailored rehabilitation based on individual patient characteristics can further enhance recovery.

Keywords: Adult orthopedic surgery, Distal radius, Functional outcome, Intra-articular fracture, Rehabilitation, Volar locking plate fixation, Wrist injuries.

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INTRODUCTION

Distal radius fractures are among the most commonly encountered skeletal injuries, particularly in the forearm region, affecting individuals across a wide age spectrum (1). With an aging global population, the incidence of these fractures is expected to rise, especially among elderly individuals and postmenopausal women who are at greater risk due to osteoporosis and reduced bone mineral density (2). However, distal radial fractures are not confined to older adults; they also constitute a significant proportion of injuries in children and adolescents, especially during sporting activities and playground accidents (3). The mechanisms and presentations vary with age, encompassing Colles', Smith, greenstick, torus, die-punch, and isolated radial shaft fractures, most commonly resulting from a fall on an outstretched hand (FOOSH) (4). Elderly patients typically experience low-energy falls from standing or sitting positions, often leading to complex, comminuted, intra-articular fracture patterns that are difficult to classify using traditional nomenclature (5). In contrast, high-energy trauma or falls from a height in younger populations produce more predictable patterns. Epidemiological evidence shows a bimodal distribution in fracture incidence, peaking in adolescence and again in the elderly, with seasonal variation and higher prevalence in winter months and regions where osteoporosis is endemic (6,7). Moreover, the lifetime risk of distal radius fracture is significantly higher in women—reported at 15–16% compared to 2–3% in men within Northern European populations (8). This gender disparity underscores the role of hormonal and metabolic factors in bone health.

Over the past decade, volar locking plate fixation has emerged as the preferred surgical approach for unstable or displaced distal radius fractures. This technique provides superior biomechanical stability and has effectively addressed many limitations associated with older methods (9). Volar locking plates are contoured implants that stabilize fracture fragments, especially in dorsally comminuted injuries, by securing screws in a fixed-angle trajectory within the subchondral bone to preserve articular congruity (10). Despite their advantages, early-generation plates with fixed-angle screw orientations posed challenges related to implant positioning and screw penetration, particularly in anatomically complex fractures (11). Technological advancements now allow for more precise placement and fixation, although some fragments—especially on the dorsal aspect—still require supplemental instrumentation (12). Studies on volar plating for intra-articular distal radius fractures have demonstrated excellent or good functional outcomes in the majority of adult patients, highlighting its clinical efficacy (13). Functionally, distal radius fractures can significantly impair wrist mobility, strength, and overall quality of life. Thus, achieving anatomical alignment and early mobilization through stable fixation is paramount to optimal recovery (14,15). While global literature supports the utility of volar locking plates, there remains a paucity of region-specific data, particularly in South Asian settings, where demographic, occupational, and lifestyle differences may influence fracture patterns and outcomes. Therefore, the objective of this study is to assess the functional outcome of volar locking plate fixation in adults with displaced intra-articular distal radius fractures at a tertiary care hospital. This research aims to bridge the local evidence gap and contribute to improving clinical decision-making and orthopedic care strategies in similar healthcare contexts.

METHODS

This descriptive quantitative study was conducted to assess the functional outcome of volar locking plate fixation in adult patients with displaced intra-articular fractures of the distal radius. The study was carried out in the Orthopedic Department of Combined Military Hospital (CMH), Peshawar, over a period of six months, following ethical approval by the institutional review board and the College of Physicians and Surgeons Pakistan (CPSP). Written informed consent was obtained from all participants after providing full disclosure regarding the objectives, procedures, and potential risks of the study. The required sample size was calculated using WHO software, based on the assumption that 10% of patients would have a fair outcome, with an absolute precision of 6% and a 95% confidence interval. This calculation yielded a target sample size of 97 participants. Eligible patients were enrolled through a non-probability consecutive sampling technique. Inclusion criteria included adult males and females aged between 18 and 69 years with radiologically confirmed displaced intra-articular fractures of the distal radius. Patients were excluded if they presented with open fractures, had concurrent fractures of the contralateral upper limb, or had existing spinal deformities that could affect upper limb function.

Baseline demographic and clinical data including age, gender, BMI, occupation, education level, income bracket, and residential background were recorded using a structured proforma. All patients underwent surgical fixation with a volar locking plate under general anesthesia. Preoperative prophylaxis included administration of 1 gram intravenous ceftriaxone. Aseptic preparation of the operative

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field was performed using povidone-iodine scrub followed by alcohol-based antiseptic. A standard volar approach using Henry's incision was utilized, with meticulous dissection to preserve the radial artery and elevate the pronator quadratus to access the fracture site. The fracture was temporarily stabilized using Kirschner wires, after which a volar locking plate was applied and secured with locking screws. Fracture reduction and implant positioning were confirmed intraoperatively with fluoroscopy using a C-arm. The surgical site was closed in layers, and a below-elbow cast was applied postoperatively for immobilization. Functional outcomes were assessed at 10 weeks following surgery using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, a standardized tool for evaluating upper limb function based on patient-reported outcomes. Outcomes were categorized into excellent, good, fair, or poor based on DASH scores. All assessments were carried out under the supervision of a senior orthopedic surgeon to ensure standardized evaluation.

Data analysis was performed using SPSS version 21. Continuous variables such as age and BMI were reported as mean ± standard deviation or median with interquartile ranges, depending on data distribution as assessed by the Shapiro-Wilk test. Categorical data were described using frequencies and percentages. To control for confounding factors such as age, BMI, type of fracture, and socioeconomic status, stratification was applied. Post-stratification comparisons were performed using Chi-square or Fisher's exact test where appropriate, with a p-value of <0.05 considered statistically significant. Patient confidentiality was strictly maintained throughout the study, and all procedures adhered to ethical standards. No additional risks were introduced beyond those involved in routine clinical care.

RESULTS

A total of 97 patients were enrolled in the study, with a mean age of 45.2 ± 12.8 years, ranging from 18 to 70 years. The study population included 59 male patients (60.8%) and 38 female patients (39.2%). The mean body mass index (BMI) was 24.6 ± 3.4 kg/m². In terms of hand dominance, the majority of patients were right-handed (85.6%), while 14.4% were left-handed. Socioeconomic status classification showed that 46.4% belonged to the low-income group, 38.1% to the middle-income group, and 15.5% to the high-income group. Functional outcomes were assessed 10 weeks postoperatively using the Disabilities of the Arm, Shoulder, and Hand (DASH) score. The mean DASH score was 28.6 ± 8.3, indicating generally favorable outcomes across the cohort. Based on DASH score classification, 45 patients (46.4%) achieved an excellent outcome with scores less than 25. Thirty patients (30.9%) were categorized as having good outcomes with scores between 26 and 35, 15 patients (15.5%) were classified as fair (scores between 36 and 45), while only 7 patients (7.2%) exhibited poor outcomes with scores exceeding 45. Stratification analysis by age revealed a trend toward better outcomes in younger patients. In the 18–35 years age group, 18 patients had excellent outcomes, 9 had good outcomes, 3 had fair, and 2 had poor outcomes. Among those aged 36–50 years, 15 had excellent results, 12 had good, 5 had fair, and 3 had poor outcomes. In the 51–70 years category, 12 had excellent outcomes, 9 had good, 7 had fair, and 2 had poor functional status. These findings suggest a positive correlation between younger age and higher functional recovery following volar locking plate fixation.

Gender-wise analysis showed that male patients achieved a slightly higher proportion of excellent outcomes compared to females. Among males, 29 patients (49.2%) achieved excellent recovery, 17 (28.8%) had good, 9 (15.3%) had fair, and 4 (6.7%) had poor outcomes. In comparison, 16 female patients (42.1%) had excellent results, 13 (34.2%) had good, 6 (15.8%) had fair, and 3 (7.9%) had poor functional recovery. Postoperative complications were infrequent and generally mild. Three patients (3.1%) experienced superficial infections, which resolved with local wound care and antibiotics. Transient median nerve irritation occurred in five patients (5.2%) and resolved spontaneously without surgical intervention. Plate loosening was reported in one case (1.0%), with no need for revision surgery. No major complications such as deep infections, tendon rupture, or hardware failure were observed throughout the follow-up period. The majority of patients (77.3%) experienced either excellent or good functional outcomes, affirming the effectiveness of volar locking plate fixation for displaced intra-articular distal radius fractures. Patients from higher socioeconomic strata appeared to recover more efficiently, indicating a possible role of social determinants in rehabilitation outcomes. These results reinforce the significance of individualized postoperative care plans tailored to patient demographics and social contexts. The data presented provides critical insights into functional recovery trends and can inform the optimization of orthopedic management protocols for distal radius fractures. The analysis of functional outcomes stratified by socioeconomic status revealed a notable trend in recovery patterns. Among patients from the high socioeconomic group, 66.7% (10 out of 15) achieved excellent outcomes, with no cases falling into fair or poor categories. In the middle-income group, 51.4% (19 out of 37) achieved excellent outcomes, while 29.7% had good results, and only a small fraction experienced fair (13.5%) or poor (5.4%) outcomes. Conversely, the low socioeconomic group demonstrated a more varied distribution, with only 35.6% (16 out of 45) achieving excellent outcomes, and a combined 35.5% falling into the fair and poor categories. These

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findings suggest that higher socioeconomic status may be positively associated with improved functional recovery, potentially due to better access to postoperative care, nutrition, rehabilitation services, and health literacy.

Table 1: Baseline Characteristics of the Study Population

Characteristic	Value
Mean Age (years)	45.2 ± 12.8
Gender Distribution	Male: 59 (60.8%)
	Female: 38 (39.2%)
Mean BMI (kg/m²)	24.6 ± 3.4
Dominant Hand	Right: 83 (85.6%)
	Left: 14 (14.4%)
Socioeconomic Status	Low: 45 (46.4%)
	Middle: 37 (38.1%)
	High: 15 (15.5%)

Table 2: Functional Outcome Categories (DASH Score)

Outcome Category	Score Range	Frequency (n)	Percentage (%)
Excellent	<25	45	46.4
Good	26-35	30	30.9
Fair	36-45	15	15.5
Poor	>45	7	7.2

Table 3: Age-wise Distribution of Functional Outcomes

Age Group (Years)	Excellent	Good	Fair	Poor
18-35	18	9	3	2
36-50	15	12	5	3
51-70	12	9	7	2

Table 4: Gender-wise Distribution of Functional Outcomes

Gender	Excellent	Good	Fair	Poor
Male	29	17	9	4
Female	16	13	6	3

Table 5: Socioeconomic Status vs Functional Outcomes

Socioeconomic Status	Excellent	Good	Fair	Poor
Low	16	13	10	6
Middle	19	11	5	2
High	10	6	0	0

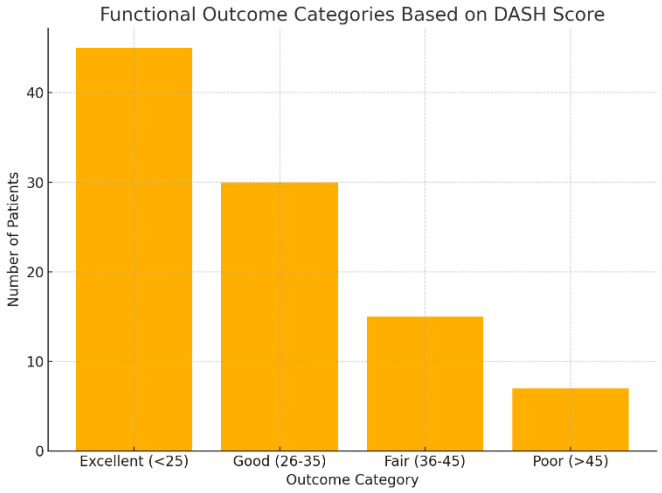

Figure 1 Functional Outcome Categories Based on DASH Score

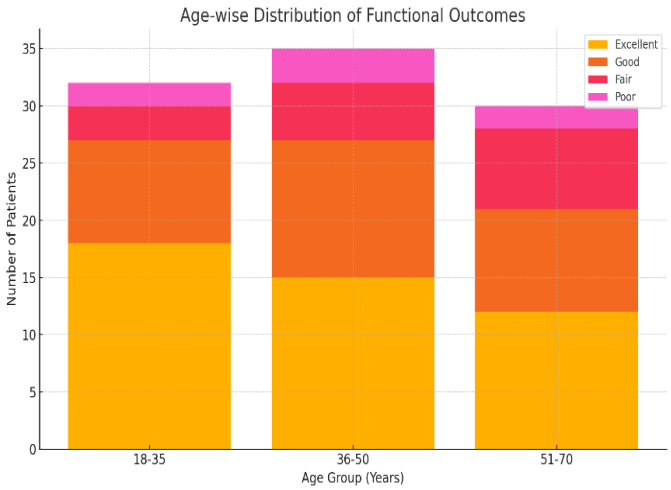

Figure 2 Age-Wise Distribution of Function Outcomes

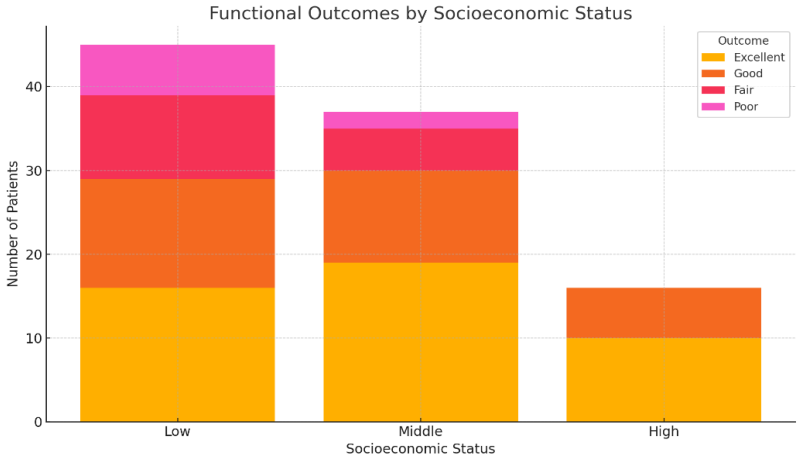

Figure 1 Functional Outcomes by Socioeconomic Status

DISCUSSION

The findings of the present study demonstrated that volar locking plate fixation is a clinically effective and functionally beneficial approach in the surgical management of displaced intra-articular fractures of the distal radius in adults. A majority of patients—77.3%—achieved either excellent or good outcomes as assessed by the DASH score, with a mean score of 28.6 ± 8.3, indicating a generally satisfactory level of function within 10 weeks postoperatively. These findings are consistent with previously published literature, where volar locking plates have been recognized for their biomechanical stability, support of articular congruity, and facilitation of early mobilization (16). Comparable studies have reported similar DASH score improvements and a low incidence of major complications, reinforcing the technique's therapeutic reliability in managing complex distal radius fractures. The study further highlighted age as a significant determinant of functional recovery. Younger patients aged 18–35 exhibited superior outcomes, with 78.3% achieving excellent function, as opposed to only 44.4% in the 51–70 age group (17). This observation is consistent with the physiological differences associated with age, including better bone density, higher regenerative capacity, and greater baseline physical activity in younger individuals. In contrast, advanced age is often associated with delayed healing, decreased compliance to rehabilitation protocols, and a higher likelihood of comorbidities that may adversely affect recovery trajectories. Such age-related variability underscores the importance of personalized treatment planning in orthopedic rehabilitation (18).

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Socioeconomic status was another influential factor, with patients from higher-income groups showing significantly better functional outcomes. Structural advantages such as better access to healthcare services, nutritional support, and postoperative rehabilitation may account for these differences. The absence of poor outcomes in the high socioeconomic subgroup compared to 13.3% in the low-income group reflects the pressing need for health equity interventions, including targeted physiotherapy programs and socioeconomic support, to reduce disparity in functional recovery. These findings align with evidence from broader public health research that emphasizes the social determinants of health in clinical outcomes. Gender analysis revealed a modest difference in outcomes, with male patients showing slightly higher rates of excellent recovery (49.2%) than female patients (42.1%). Although the difference was not statistically significant, it may relate to differences in bone architecture, occupational exposure, or adherence to rehabilitation routines. Nonetheless, the generally favorable outcomes in both sexes reinforce the applicability of volar locking plate fixation as a gender-neutral surgical approach (19). The study recorded a low complication rate, with only minor events such as superficial infections (3.1%), transient median nerve irritation (5.2%), and plate loosening (1.0%). No major complications such as deep infections, tendon rupture, or hardware failure were encountered. This supports the procedural safety of volar locking plate fixation when performed under meticulous surgical technique and within the framework of evidence-based perioperative protocols. These outcomes are consistent with previous clinical audits and multicenter studies, which have emphasized the importance of surgeon experience and intraoperative precision in minimizing adverse events (20).

From a clinical standpoint, the findings underscore the relevance of individualized surgical care. Attention to soft tissue handling, precise implant placement, and structured postoperative rehabilitation contributed substantially to the positive outcomes. The study supports the integration of patient-specific variables such as age and socioeconomic status into surgical planning and postoperative follow-up. It also reinforces the necessity for early mobilization to enhance functional recovery, in line with international rehabilitation standards. Despite its strengths, the study was limited by a relatively short follow-up duration of 10 weeks, which may not capture long-term complications or delayed functional deficits. Moreover, as a single-center study, the findings may not be universally generalizable due to variations in surgical expertise, hospital infrastructure, and patient demographics across institutions. The use of a non-randomized, consecutive sampling method introduced potential selection bias, limiting the internal validity of the results. Additionally, the sample size, while statistically justified, could benefit from expansion to enhance subgroup analyses and external applicability. Future research should consider multicenter trials with longer follow-up periods to explore the durability of functional outcomes and potential late complications such as post-traumatic arthritis or implant-related issues. Comparative studies evaluating volar locking plate fixation against alternative surgical or conservative treatments would also be valuable in defining optimal management pathways. Furthermore, research into the role of psychosocial factors, occupational demands, and health literacy in rehabilitation outcomes may offer nuanced insights for tailoring postoperative care. In conclusion, volar locking plate fixation remains a valid and effective surgical technique for the management of displaced intra-articular distal radius fractures in adults. Its favorable functional outcomes, minimal complication profile, and broad applicability across patient demographics affirm its role in contemporary orthopedic practice. Optimizing patient-centered approaches and addressing contextual challenges through further research will be instrumental in refining the quality and consistency of care for distal radius fractures.

CONCLUSION

This study concludes that volar locking plate fixation is an effective and reliable surgical approach for managing AO type C distal radius fractures in adults, offering favorable functional recovery and minimal complications. The findings emphasize the role of patient-specific factors such as age and socioeconomic status in influencing rehabilitation outcomes, highlighting the need for personalized postoperative care strategies. The technique's mechanical stability and support for early mobilization make it a valuable tool in orthopedic fracture management. By reinforcing existing evidence and drawing attention to key clinical and demographic variables, this research contributes meaningfully to the refinement of fracture treatment protocols and supports the broader adoption of volar locking plate fixation in surgical practice.

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AUTHOR CONTRINUTION

Author	Contribution
Muhammad Aamir*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Ejaz Ashraf Mallhi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Bilal Khan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Adeel Habib	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Kashan Shahid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shah Abdurrahim	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muhammad Tayyab Sajjad	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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