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A Remote Rehabilitation Program for Improving Arm Function Following Elbow Fractures in the Adult Population: Pilot study

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Abstract: ***The elbow is an anatomically complex joint prone to complications and functional impairments following trauma. Telerehabilitation has emerged as a promising approach to deliver rehabilitation services remotely using information and communication technologies. This pilot study aimed to investigate the efficacy of a tele-rehabilitation program for improving upper limb function among adults following elbow fractures. Pilot study was conducted including 16 patients aged between 20 and 40 years who had completed the immobilization phase following elbow fracture. Participants were randomly divided into two groups: group A (n=8) received conventional face-to-face physiotherapy sessions three times per week, while group B (n=8) received telerehabilitation sessions three times per week for 30 minutes each. Outcomes were measured using goniometry for range of motion, the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire, and the Patient-Rated Elbow Evaluation (PREE). Both groups demonstrated significant improvements in elbow flexion, extension, supination, and pronation post-intervention (p<0.05). Significant reductions were also observed in disability scores, pain levels, and limitations in performing specific and usual activities. However, no statistically significant differences were found between the two treatment approaches across all outcome measures (p>0.05). Both telerehabilitation and conventional face-to-face physiotherapy are effective approaches for improving upper limb function among adults following elbow fractures. Telerehabilitation represents a viable alternative that can enhance accessibility to rehabilitation services.***

Keywords: Telerehabilitation; Elbow Fracture; Upper Limb Function; Conventional Physiotherapy.

1. Introduction

The elbow represents one of the most anatomically complex joints in the human body, characterized by its intricate articulating surfaces, ligamentous structures, and neurovascular supply that collectively enable essential upper limb functions [1]. Following traumatic injuries such as fractures, patients frequently experience complications including restricted range of motion (ROM), persistent pain, joint instability, heterotopic ossification, and stiffness that can profoundly impact activities of daily living [2]. Research has demonstrated that even a 50% reduction in elbow function may lead to an 80% decrease in daily activity performance, underscoring the critical importance of effective rehabilitation strategies [3]. While most evidence-based literature supports early joint mobilization to restore limb function, there remains limited research examining the efficacy of active interventions, with many existing protocols relying primarily on clinical experience rather than empirical evidence [4]. Concurrently, telerehabilitation has emerged as a promising therapeutic modality that enables clinicians to perform evaluation and treatment using communication technologies, with studies demonstrating its effectiveness in motor recovery following neurological conditions such as stroke and traumatic brain injuries [5].

The primary objective of the pilot study was to investigate the efficacy of a tele-rehabilitation program for improving upper limb function among adults following elbow fractures, while also examining whether significant differences exist based on demographic variables including age, gender, injured hand, hand dominance, and fracture type. The research was guided by the hypothesis that telerehabilitation would demonstrate comparable efficacy to conventional face-to-face treatment in improving upper limb function. This investigation addresses a critical gap in the literature, as limited previous studies have examined telerehabilitation specifically following elbow fractures, despite its potential advantages including reduced healthcare costs, improved treatment adherence, and enhanced patient satisfaction through remote service delivery [6]. The rationale for this study stems from the necessity for physiotherapists to utilize evidence-based tools in clinical practice and the importance of empirical research evaluating treatment outcomes, particularly given that sufficient active elbow ROM is essential for maintaining normal daily activities and quality of life [7].

2. Methodology

2.1 Study Design

A pilot study was conducted at Palestine Ahliya University from November to December 2025. Sixteen patients aged between 20 and 40 years who had completed the elbow fixation phase and required physiotherapy as determined by their physicians. Patients were randomly divided into two groups: the telerehabilitation group (Group B, n=8) and the conventional treatment control group (Group A, n=8).

Group A received three conventional face-to-face sessions per week, each lasting 30 minutes, which included active ROM exercises (flexion, extension, pronation, and supination) using therapeutic accessories such as theraband and balls, along with hot pack application to address joint and soft tissue stiffness. Group B received three telerehabilitation sessions per week, each lasting 30 minutes, consisting of identical exercise protocols delivered remotely. All participants commenced treatment immediately following the removal of elbow fixation. The study received approval from hospital administrations, medical centers, and the university administration. All participants provided informed consent through forms written in Arabic containing complete study details. Participants retained the right to withdraw at any time, and researchers ensured full protection of participant safety and confidentiality of all personal information.

2.2 Instrumentation and Outcome Measures

Data collection utilized multiple validated instruments. A demographic questionnaire and medical records provided information on age, gender, injured hand, hand dominance, and fracture type. Range of motion was measured using a manual goniometer for elbow flexion, extension, forearm supination, and pronation. Functional outcomes were assessed using two standardized questionnaires: The Disabilities of Arm, Shoulder and Hand (DASH) questionnaire, a 30-item self-assessment tool evaluating functioning and symptom severity with scores ranging from 0 to 100 (higher scores indicating poorer functioning), which has demonstrated high repeatability in elbow injury populations (ICC=0.92). Additionally, the Patient-Rated Elbow Evaluation (PREE) assessed pain levels and functional limitations using a Likert scale (0-10), encompassing five pain-related questions, 11 questions regarding specific task performance, and four questions related to usual daily activities.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria comprised patients aged 20-40 years who had completed the elbow fixation phase. Exclusion criteria included neurological or orthopedic diseases that could affect upper extremity function.

Data Collection and Statistical Analysis

Patient demographic data were obtained prior to intervention. The 16 patients were randomly distributed into two groups: Group A (conventional sessions) and Group B (telerehabilitation sessions) based on inclusion and exclusion criteria. Statistical analysis was performed using SPSS version 26.0, employing descriptive and frequency statistics, means, standard deviations, and percentages. Continuous variables were presented as mean ± standard deviation, while categorical variables were presented as numbers and percentages. T-tests and One-Way ANOVA were used to examine differences related to demographic variables, and independent samples t-tests were employed to identify differences between groups.

3. Results

Demographic Characteristics

Analysis of demographic characteristics revealed that 75% of participants in both groups were aged 20-30 years, while 25% were aged 31-40 years. In Group A, males constituted 62.5% and females 37.5%, while Group B demonstrated equal gender distribution (50% each). Regarding injured hand, 37.5% of participants in both groups sustained right-sided injuries and 62.5% left-sided injuries. Right-hand dominance was reported by 62.5% of participants in both groups, with left-hand dominance in 37.5%. Fracture types in Group A comprised 62.5% radial head fractures and 37.5% olecranon fractures, while Group B demonstrated 75% radial head and 25% olecranon fractures. Statistical analysis confirmed no significant differences between groups across all demographic variables ($p>0.05$), ensuring group comparability at baseline. The results shown in Table 1.

Table 1: Demographic Characteristics of Participants

Characteristic	Category	Group A (Conventional) (n=8)	Group B (Telerehab) (n=8)	Total (N=16)	P-value
Age	20-30 years	6 (75%)	6 (75%)	12 (75%)	>0.05
	31-40 years	2 (25%)	2 (25%)	4 (25%)	
Gender	Male	5 (62.5%)	4 (50%)	9 (56.25%)	>0.05
	Female	3 (37.5%)	4 (50%)	7 (43.75%)	
Injured Hand	Right	3 (37.5%)	3 (37.5%)	6 (37.5%)	>0.05
	Left	5 (62.5%)	5 (62.5%)	10 (62.5%)	
Hand Dominance	Right	5 (62.5%)	5 (62.5%)	10 (62.5%)	>0.05
	Left	3 (37.5%)	3 (37.5%)	6 (37.5%)	
Fracture Type	Radial Head	5 (62.5%)	6 (75%)	11 (68.75%)	>0.05
	Olecranon	3 (37.5%)	2 (25%)	5 (31.25%)	

3.1 Within-Group Comparisons

Group A (Conventional Treatment): Paired samples analysis demonstrated significant improvements across all outcome measures following conventional face-to-face treatment. Elbow flexion increased from 111.25°±15.97 to 127.62°±11.33 ($p=0.002$), representing a mean difference of 16.37°. Extension improved from 14.62°±11.45 to 8.50°±7.95 ($p=0.006$), indicating reduced extension deficit. Supination increased from 40.00°±17.90 to 62.12°±16.96 ($p<0.001$), while pronation improved from 43.00°±23.34 to 60.87°±21.62 ($p<0.001$). The DASH disability score decreased significantly from 78.41±4.17 to 47.27±5.91 ($p<0.001$). Pain scores reduced from 41.00±3.12 to 22.37±5.66 ($p<0.001$), and disability in performing specific and usual activities decreased from 36.87±2.15 to 17.85±6.09 ($p<0.001$). Total PREE scores improved from 77.87±4.08 to 40.22±11.48 ($p<0.001$).

The results shown in Table 2.

Table 2: Within-Group Comparison for Group A (Conventional Treatment)

Outcome Measure	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Difference	P-value
Elbow Flexion (°)	111.25 ± 15.97	127.62 ± 11.33	16.37°	0.002
Elbow Extension (°)	14.62 ± 11.45	8.50 ± 7.95	-6.12°	0.006
Forearm Supination (°)	40.00 ± 17.90	62.12 ± 16.96	22.12°	<0.001
Forearm Pronation (°)	43.00 ± 23.34	60.87 ± 21.62	17.87°	<0.001
DASH Score (0-100)	78.41 ± 4.17	47.27 ± 5.91	-31.14	<0.001
PREE - Pain (0-50)	41.00 ± 3.12	22.37 ± 5.66	-18.63	<0.001
PREE - Activity (0-110)	36.87 ± 2.15	17.85 ± 6.09	-19.02	<0.001
PREE - Total Score (0-160)	77.87 ± 4.08	40.22 ± 11.48	-37.65	<0.001

SD: Standard Deviation; DASH: Disabilities of Arm, Shoulder and Hand; PREE: Patient-Rated Elbow Evaluation. °

Group B (Telerehabilitation): Comparable improvements were observed following telerehabilitation intervention. Elbow flexion increased from 113.37°±15.01 to 131.75°±8.03 (p=0.001), a mean difference of 18.37°. Extension improved from 11.75°±9.97 to 6.12°±7.97 (p=0.005). Supination increased from 39.25°±19.28 to 58.75°±17.27 (p<0.001), and pronation improved from 39.62°±21.84 to 56.62°±21.03 (p<0.001). DASH scores decreased significantly from 67.58±9.02 to 44.77±11.09 (p=0.001). Pain scores reduced from 37.62±7.73 to 21.75±10.50 (p=0.037), while disability in activities decreased from 31.66±7.26 to 18.81±8.66 (p=0.046). Total PREE scores improved from 69.28±14.70 to 40.56±18.91 (p=0.040). The results shown in Table 3.

Table 3: Within-Group Comparison for Group B (Telerehabilitation)

Outcome Measure	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Difference	P-value
Elbow Flexion (°)	113.37 ± 15.01	131.75 ± 8.03	18.38°	0.001
Elbow Extension (°)	11.75 ± 9.97	6.12 ± 7.97	-5.63°	0.005
Forearm Supination (°)	39.25 ± 19.28	58.75 ± 17.27	19.50°	<0.001
Forearm Pronation (°)	39.62 ± 21.84	56.62 ± 21.03	17.00°	<0.001
DASH Score (0-100)	67.58 ± 9.02	44.77 ± 11.09	-22.81	0.001
PREE - Pain (0-50)	37.62 ± 7.73	21.75 ± 10.50	-15.87	0.037
PREE - Activity (0-110)	31.66 ± 7.26	18.81 ± 8.66	-12.85	0.046
PREE - Total Score (0-160)	69.28 ± 14.70	40.56 ± 18.91	-28.72	0.040

SD: Standard Deviation; DASH: Disabilities of Arm, Shoulder and Hand; PREE: Patient-Rated Elbow Evaluation.

3.2 Between-Group Comparisons

Independent samples t-test revealed no statistically significant differences between conventional treatment and telerehabilitation across all outcome measures. For elbow flexion, the mean difference between groups was not significant (p=0.646). Extension improvements showed no significant between-group differences (p=0.803). Supination (p=0.448) and pronation (p=0.831) improvements were comparable between groups. DASH score reductions demonstrated no significant differences (p=0.229). Pain evaluation (p=0.090), activities evaluation (p=0.697), and total PREE scores (p=0.224) all showed non-significant differences between treatment approaches. Analysis of demographic variables revealed no significant differences in outcomes based on age (p=0.06), gender (p=0.72), injured hand (p=0.55), hand dominance (p=0.06), or fracture type (p=0.32). The results shown in Table 4.

Table 4: Between-Group Comparison (Conventional vs. Telerehabilitation)

Outcome Measure	Group A (Conventional) Post-Tx Mean ± SD	Group B (Telerehab) Post-Tx	Mean Difference	P-value
Elbow Flexion (°)	127.62 ± 11.33	131.75 ± 8.03	4.13	0.646
Elbow Extension (°)	8.50 ± 7.95	6.12 ± 7.97	-2.38	0.803
Forearm Supination (°)	62.12 ± 16.96	58.75 ± 17.27	-3.37	0.448
Forearm Pronation (°)	60.87 ± 21.62	56.62 ± 21.03	-4.25	0.831
DASH Score (0-100)	47.27 ± 5.91	44.77 ± 11.09	-2.50	0.229
PREE - Pain (0-50)	22.37 ± 5.66	21.75 ± 10.50	-0.62	0.090
PREE - Activity (0-110)	17.85 ± 6.09	18.81 ± 8.66	0.96	0.697
PREE - Total Score (0-160)	40.22 ± 11.48	40.56 ± 18.91	0.34	0.224

Tx: Treatment; SD: Standard Deviation; DASH: Disabilities of Arm, Shoulder and Hand; PREE: Patient-Rated Elbow Evaluation. P-values > 0.05 indicate no statistically significant difference between groups.

4. Discussion

The findings of this study demonstrate that both conventional face-to-face physiotherapy and telerehabilitation are effective interventions for improving upper limb function among adults following elbow fractures. The significant improvements observed in range of motion, functional disability, pain levels, and activity performance within both groups align with previous research supporting the importance of early mobilization and structured rehabilitation following elbow trauma [8]. These results are consistent with recent systematic reviews indicating that telerehabilitation produces comparable clinical outcomes to traditional in-person therapy across various musculoskeletal conditions [9].

The absence of statistically significant differences between the two treatment modalities is particularly noteworthy, as it suggests that telerehabilitation can serve as a viable alternative to conventional care. This finding supports the work of Mayer et al. [10], who reported similar improvements in range of motion and

functional assessments between telerehabilitation and conventional treatment groups following elbow fractures, though their study noted higher patient satisfaction and reduced family assistance requirements in the telerehabilitation group [10]. The comparable efficacy between modalities may be attributed to the standardized exercise protocols delivered in both settings, suggesting that treatment content, rather than delivery method, may be the primary determinant of outcomes.

The significant improvements in pain reduction observed in both groups are consistent with findings from Janela et al. [11], who demonstrated that digital care programs incorporating exercise, education, and cognitive-behavioral approaches resulted in substantial pain reduction and decreased productivity impairment in patients with elbow musculoskeletal conditions [11]. Similarly, Tousignant et al. [12] reported significant improvements in pain and upper limb function following in-home telerehabilitation for proximal humerus fractures, with high patient satisfaction ratings comparable to traditional care [12]. These converging findings across different upper extremity conditions strengthen the evidence base for telerehabilitation as an effective service delivery model.

The lack of significant differences based on demographic variables including age, gender, and fracture type suggests that telerehabilitation may be broadly applicable across diverse patient populations. This finding has important implications for healthcare accessibility, particularly for patients in rural or underserved areas, those with transportation difficulties, or individuals with work or caregiving responsibilities that limit clinic attendance [13]. The COVID-19 pandemic has further accelerated the need for remote healthcare delivery options, and the present findings support the continued integration of telerehabilitation into standard practice [14].

However, several considerations warrant discussion when interpreting these results. The small sample size limits statistical power and generalizability, a limitation shared with previous pilot studies in this area [15]. Additionally, the short intervention period of one month may not capture longer-term outcomes or potential differences in maintenance of gains between groups. The absence of blinding in outcome assessment may introduce measurement bias, though the use of standardized, validated instruments partially mitigates this concern.

The mechanisms underlying the comparable effectiveness of telerehabilitation may relate to enhanced patient engagement and adherence when using remotely delivered programs. Moulaei et al. [16] identified that telerehabilitation systems increase patient interest, motivation, and adherence to rehabilitation exercises, leading to greater participation in treatment processes [16]. Furthermore, the ability to perform exercises in the home environment may facilitate the transfer of gains to functional activities and promote greater independence in self-management [17]. The real-time monitoring and feedback capabilities of telerehabilitation platforms may also enable clinicians to provide timely corrections and adjustments, potentially compensating for the lack of physical presence [18].

Based on the study findings, several recommendations are proposed for clinical practice and future research. Clinicians should consider incorporating telerehabilitation programs into treatment frameworks for patients following elbow fractures, given the equivalent outcomes achieved compared to conventional care. The DASH and PREE questionnaires should be utilized routinely in clinical practice and research to systematically evaluate patient outcomes and track recovery trajectories. Future research should include larger sample sizes, longer follow-up periods, and examination of cost-effectiveness to strengthen the evidence base. Healthcare institutions should invest in telerehabilitation infrastructure and training to expand service accessibility, particularly for underserved populations.

The primary limitations of this study include the small sample size, which limits statistical power and generalizability, and the short intervention duration that precludes assessment of long-term outcomes. The absence of blinding in outcome assessment and the single-center design may introduce bias. Additionally, the study did not examine patient satisfaction, cost-effectiveness, or potential barriers to telerehabilitation implementation, representing important areas for future investigation.

5. Conclusion

This study provides evidence that telerehabilitation is an effective alternative to conventional face-to-face physiotherapy for improving upper limb function among adults following elbow fractures. Both treatment approaches resulted in significant improvements in range of motion, pain reduction, functional ability, and performance of daily activities, with no statistically significant differences between modalities. These findings support the integration of telerehabilitation into standard clinical practice, particularly for patients facing barriers to accessing traditional in-person services. The comparable outcomes between groups suggest that treatment content and patient adherence may be more critical determinants of success than the specific mode of service delivery.

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