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Feasibility of the PERFormance guided fracture Rehabilitation Method (PERFoRM) protocol for upper extremity fractures

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Purpose: **Upper extremity fractures are increasingly common in Western Europe due to an aging population and rising osteoporosis rates. Treatment approaches vary significantly, influenced by fracture type, bone quality, and patient-surgeon preferences, with limited consensus on optimal rehabilitation. A key challenge is identifying when to initiate safe, early functional rehabilitation, as guidelines lack clarity on progressive mobilization.**

Materials & Methods: **A prospective observational study of operatively treated proximal humeral and distal radius fractures was performed. Feasibility was assessed through clinical observation of patient progress using patient-reported outcome measures and feedback from both medical and paramedical professionals.**

Results: **Twenty patients and 10 professionals participated. Feasibility questionnaires indicated high protocol usability, though suggestions included simplifying it into a pocket card. Rapid functional improvement was observed within six weeks, with one complication (material failure) noted.**

Conclusion: **The PERFoRM protocol is safe and feasible, though larger-scale studies are needed. Future research should examine its applicability to a broader patient population, potentially extending to all upper extremity fractures except hand fractures.**

Keywords: Permissive load bearing, Permissive weight bearing, Protocol, Rehabilitation, Trauma, Treatment, Upper extremity fractures.

INTRODUCTION

Proximal humeral fractures (PHF) and distal radius fractures (DRF) are common and rank as the first and third most frequently encountered non-vertebral fractures[1,2]. Over the years, more and more patients in Western Europe have sought emergency care for upper extremity (UE) fractures after an accident[3,4]. With increasing age of the population and prevalence of osteoporosis, the incidence of fractures is expected to rise further[1,5,6].

Upper extremity fractures profoundly impact daily activities and functional status, often leading to physical deconditioning. Consequently, mortality following UE fractures tends to linearly increase in the initial post-fracture years, suggesting a modest impact[7,8].

Treatment for UE fractures are influenced by factors like fracture type, bone quality and patient-surgeon preferences[9,10]. There is limited consensus about the aftercare, the role of load bearing and performance guided rehabilitation after trauma regarding PHF and DRF, which is in line with recent literature[11].

One of the most pressing clinical questions is how early functional rehabilitation can be safely initiated[12-15]. Synergistic analysis of findings and broad implementation into medical guidelines is however hindered, because permissive load bearing (PLB) can be broadly interpreted and clear guidance is lacking[16]. For example the definition of allowed mobilization, and exercises used, as well as milestones for progression, and a comparison with a more conservative approach have not yet been delivered.

In light of these challenges, this study assesses the feasibility of implementing a well-defined performance guided rehabilitation protocol for UE fractures, i.e. the PERFormance guided fracture Rehabilitation Method

(PERFoRM) protocol. PERFoRM aims to offer a fracture-and-patient guided structured framework, optimizing recovery and restoring activity and participation levels following upper extremity fractures.

MATERIALS AND METHODS

Study design

A prospective observational single center study was performed between April 2022 and November 2023 at Zuyderland Medical Center, Heerlen, the Netherlands. In this study, we assessed the feasibility of the PERFoRM protocol for patients with peri-articular fractures of the upper extremity (proximal humeral fractures and distal radius fractures). Feasibility was assessed by 1. Clinical observation of patient progress with use of PROMs and objective observations of (para-) medical professionals. Secondary outcome measures were recovery based on the ICF domains (health condition, activities and participation in society) and complications observed during rehabilitation. 2. Qualitative feedback was inquired and received from health care practitioners prior to the initiation of treatment for feasibility assessment and again upon completion of the treatment.

Inclusion criteria were patients presenting with a surgically treated proximal humeral or distal radius fracture, age between 18-70, adequate premorbid functional status defined as at least the capability for independent living and proficiency in Activities of Daily Living (ADL) and/or Home Daily Living (HDL) activities, ability to attend treatment sessions/ appointments at the Rehabilitation Department of Zuyderland Medical Center and were able to follow the instructions of the protocol (Dutch/English). Patients were excluded if they suffered multiple fractures within a single limb, pathological fractures, presence of complications such as trophic dysregulation and/ or Complex Regional Pain Syndrome (CRPS) at time of inclusion, extensive accompanying neurovascular injury, cognitive impairment affecting learnability and instructability, influential psychological issues or active substance abuse ((with the exception of trauma related (motion) anxiety or potential Post-Traumatic Stress Disorder (PTSD)) and subjects unwilling to adhere to the principles of informed consent. Ethical approval was obtained from the Medical Ethics Committee Zuyderland & Hogeschool Zuyd (METCZ20210184).

Study protocol and assessments

All patients with upper extremity fractures were post-operatively included and treated according to the PERFoRM protocol for three months (Figure 1). Inclusion took place within the Multi-Disciplinary Trauma Unit (MDTU) of Zuyderland Medical Center in Heerlen at outpatient clinic appointments with the orthopedic or trauma surgeon. After inclusion, assessment points were scheduled at 0-2 week, 6 weeks, 12 weeks and 6 months post-operatively.

The ICF-model was employed to assess the level of recovery using various measurements. Impairment was evaluated through use of the handgrip strength (JAMAR hand-dynamometer, Fysiosupplies B.V., Groningen), NPRS, Quick-DASH and RAND-36. Daily activities and quality of life were evaluated through the milestones, Quick-DASH and RAND-36. The evaluation of the balance between load and load capacity and the screening for potential complications was carried out using the flags checklist (Figure 3). Lastly, the Quick-DASH and RAND-36 provided an estimation of the patient's level of participation in society. For Quick-DASH, a patient-acceptable symptom state (PASS) has been established at score < 16[17].

Elements of the protocol

Within the rehabilitation process guided by the PERFoRM protocol for upper extremity fractures,

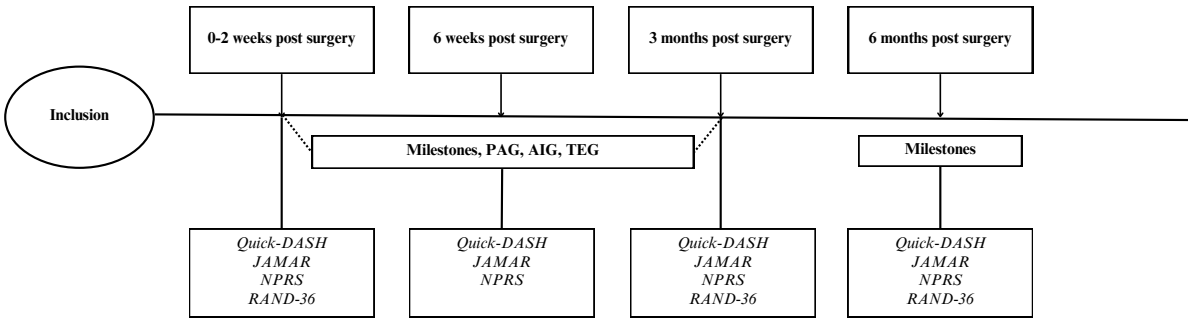

Fig. 1 — Study procedure.

PAG = patient assessment guide; AIG = aims identification guide; TEG = treatment evaluation guide ; Quick-DASH = disabilities of the arm, shoulder and hand ; JAMAR = strength-hand held dynamometer; NPRS = number pain rating scale; RAND-36 = research and development-36.

the progression of functional activities and the gradual increase in fracture load are determined by the patient's subjective experience in conjunction with the objectively assessable clinical presentation of both the patients and the fracture. The patients subjective experience encompasses aspects such as pain perception and the confidence to bear weight. Progression is not solely determined by fracture consolidation but is influenced by a complex interplay of biopsychosocial factors. Ultimately, the quality of movement becomes decisive for the rehabilitation progress in activity performance.

The practical implementation of the PERFoRM protocol is grounded in four key elements displayed in Figure 2:

1. Patient Assessment Guide (PAG)
2. Treatment Guide (TG)
3. Treatment Evaluation Guide (TEG)
4. Aims Identification Guide (AIG)

Patient Assessment Guide (PAG):

PAG or patient characteristics encompass predictors that have the potential for predicting progression, consolidation, load bearing capacity, the risk of complications, and rehabilitation potential for individual patients undergoing fracture rehabilitation. Mapping patient characteristics reveals factors that may have either a positive or negative effect on fracture recovery and therapy outcomes. Additionally, the PAG aims to form a patient profile, assisting in determining the therapy intensity and expected activity level post-rehabilitation. Annex A contains the form that elucidates the patient profile.

Treatment Guide (TG):

The TG delineates the treatment plan (see Annex B), encompassing physiotherapeutic methodical practices wherein therapeutic interventions and dosages are related to all three ICF domains. At the

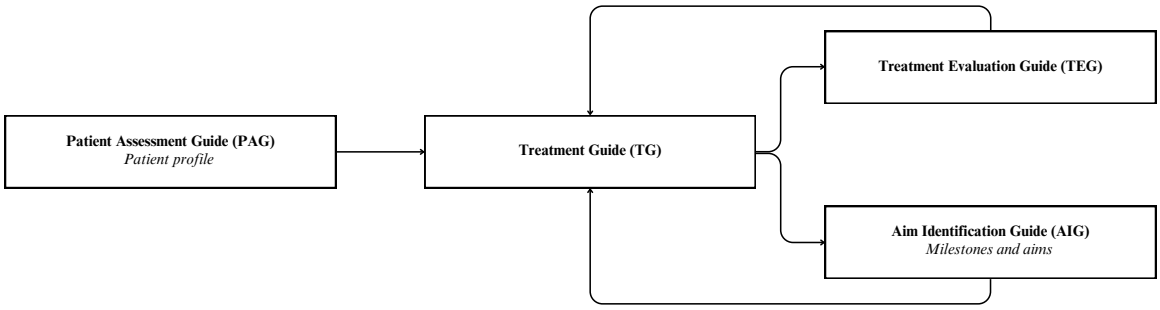

Fig. 2 — Base elements of the protocol.

Treatment Evaluation Guide (TEG)	Status
Pain	
Temperature	
Erythema	
Cyanosis	
Neurological status	
Vascular status	
Position of fracture	
Load tolerance	
Soft tissues	
Range of motion	
Compliance	
Medication	
Edema	
Wound healing	

Fig. 3 — Checklist with usage of flag methodology.

functional level, focus is directed to controlling edema and hydrops, improving circulation, maintaining or enhancing joint mobility, and improving muscle function, endurance, and coordination. The TG, in addition to disorder-level intervention, includes functional training at the levels of activities and participation, specifically aimed at achieving the individual patient's goals. This focuses on skills such as reaching, pushing, pulling, and supporting, which serve as prerequisites for application in specific activities.

Treatment Evaluation Guide (TEG):

The TEG is twofold: administering a routine checklist of classic performance indicators: partly subjectively scored against expectation.

Throughout the course of treatment, a flagging methodology is employed to screen the extent to which the rehabilitation progression/intensity leads to unwanted symptoms or complications (Figure 3). Various clinically observable areas, such as pain, temperature, and swelling, are evaluated for the effects of the rehabilitation process. One yellow flag on any aspect warrants specific attention and potential treatment adjustment. A red flag needs medical evaluation.

Aims Identification Guide (AIG): Milestones and Aims

Throughout the rehabilitation process, goals are formulated based on the patient's needs, providing direction to rehabilitation efforts and varying on an individual basis. Generic and patient-specific milestones/goals are articulated by the patient and recorded in the patient's medical record. Unlike current rehabilitation protocols, PERFoRM utilizes these goals as evaluation tools in the form of milestones. Specific milestones have been defined for upper extremity function, enabling the assessment of progress during the rehabilitation process, as for example wash hair, bring food to the mouth and dressing the upper extremity (see appendix C).

Statistical analysis

All analyses were performed with SPSS version 29.0 software (SPSS Inc., Chicago, USA). First data were analyzed for normality (Kolmogorov test). Not-normally distributed data was analyzed with non-parametric statistics (Mann–Whitney U test). Continuous variables were described using means (±SD) or with median (IQR) if data was non-parametric. Categorical variables were tested with Chi-square tests and tabulated with absolute frequencies (and as %). Descriptive statistics were used to display the demographic data and quantitative information obtained from the protocol components. Duration until milestones achieved was assessed by reverse survival analysis with Kaplan-Meier plots. A p-value of 0.05 was considered statistically significant.

RESULTS

A total of 20 patients were included between April 2022 and November 2023. Due to disproportionate data, we opted to present the data from 19 patients to enhance the precision of the results. One patient was lost-to-follow-up due to not being able to come to the appointments due to transportation issues and one patient suffered a new fall with a new fracture.

Patient characteristics

Demographic and injury characteristics are shown in Table I. The group consisted of 1 PHF and 19 DRF. The median age was 57 and 79% was female in our study population. The majority of fractures occurred due to low-energy trauma and in 42% of the cases the dominant arm was affected. In total, 1 patient had a complication related to the surgery (material failure) for which the patient underwent revision surgery with a successful outcome.

Milestones

More than 50% of patients were able to perform light ADL activities, such as washing arm pits, dressing the upper extremity and combing hair within six weeks. By the end of the follow-up period, close to 100% of the patients were able to resume these activities. More intense activities related to Home Daily Living (HDL) such as opening a jar, changing bed sheets and opening heavy doors was achieved by 50% of patients after 12 weeks. Approximately 80% of patients were able to fully resume these activities after 12 weeks (see figure 4).

The results indicate that considerable effort is required for self-care related actions in the first six weeks, warranting adequate compensation or support. Similarly, activities such as opening a jar, changing bed sheets and opening heavy doors exhibit the same trend, yet showing somewhat slower recovery with 20-40% of patients still compensate these activities at three months, and ~20% even at 6 months (see Figure 5). Data on all 20 milestones is attached in the Supplementary Material.

Table I. — Patient characteristics.

	Number of patients (n=19)
Sex	
Female (n=%)	15 (79%)
Male (n=%)	4 (21%)
Age (median, Min-Max)	57 (37-70)
ASA-classification (median, IQR)	2 (1-3)
Days in hospital	0.5 - 1.2 (1-3)
Co-morbidities	
Osteoporosis	1
Diabetes mellitus	1
COPD	0
Cardiac condition	1
Vascular disease	0
Smoking	1
Alcohol consumption	0
Trauma mechanism	
High-energetic (n=%)	3 (16%)
Low-energetic (n=%)	16 (84%)
Multi-trauma patient	
Yes (n=%)	1 (5%)
No (n=%)	18 (95%)
Fracture type	
Proximal humeral fracture	1
Distal radius fracture	19
Type of fracture	
Intra-articular	16
Extra-articular	3
Complications	1
Dominant hand	
Yes (n=%)	8 (42%)
No (n=%)	11 (58%)
Pain medication	
NSAIDs	2 (11%)
Opioids	1 (5%)
Corticosteroids	0

PROMs (Quick-DASH, NPRS, RAND-36) and Handgrip strength

PROMs demonstrated rapid functional progress within the first 12 weeks of the recovery process (see figure 6). After 6 weeks, almost all patients mention a NPRS of 1.5 or less. By 12 weeks, the vast majority of the study population has been able to return to their previous jobs or is able to engage in sports. The Quick-DASH score shows persistent disabilities after 24 weeks of recovery in ~30% of patients (N=5), who did not reach PASS-scores of <16. Handgrip strength measurements showed slow regain of strength up until ~ 75% of the contralateral hand (see Figure 6 D-E). These outcomes were not different between the dominant vs. non-dominant hand being injured (Figure 6F).

Qualitative

A total of 10 health care workers completed the questionnaires about the feasibility of the protocol: 1 orthopaedic surgeon, 1 trauma surgeon, 1 rehabilitation physician and 7 paramedics (physiotherapists and occupational therapists). In all instances, the objective of the protocol was clear, and it proved easy to use. A significant advantage of the protocol was that it considered both medical and paramedical aspects of the post-treatment trajectory according to the physicians, providing a comprehensive overview. As

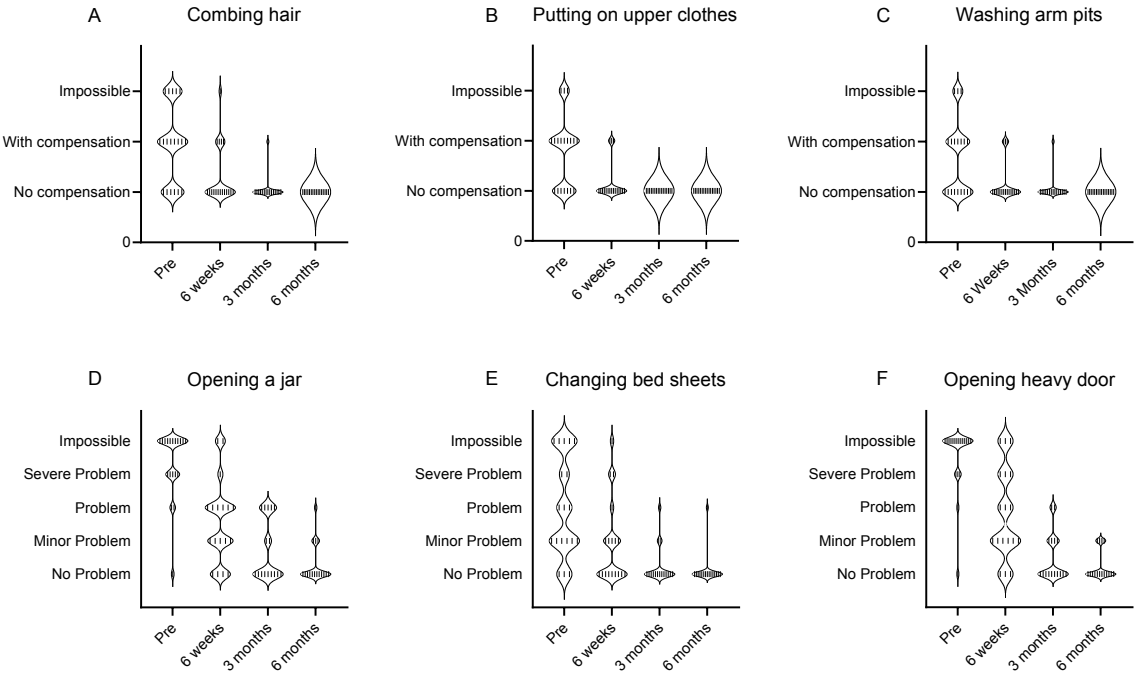

Fig. 4 — ADL and HDL proportions.

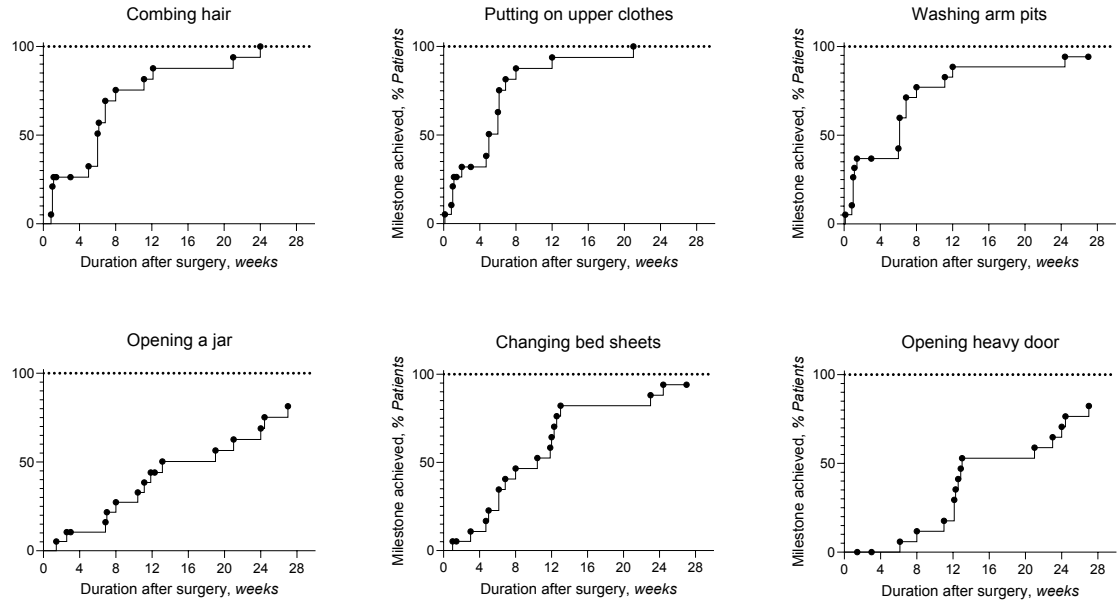

Fig. 5 — ADL and HDL functional rehabilitation.

areas for improvement, it was noted that completing the protocol was time-consuming (ranging from 5 minutes to 1.5 hours), and it was suggested that the protocol could be shortened with possibly other abbreviations to enhance usability (see Table II).

DISCUSSION

Main findings

In the present study, we have investigated the feasibility of the PERFoRM protocol for operatively treated upper extremity fractures. The present study showed that the protocol is feasible in practice for both medics and paramedics, providing a structured performance based rehabilitation framework with clear milestones. The majority of the respondents approved the content and milestones of the protocol, while suggested shortening of the volume of protocol to reduce reading time. From a patient-perspective, outcomes showed rapid functional progress in the first 0-6 weeks after surgery, while one complication was observed during rehabilitation.

Table II. — Strengths and improvements based on the feasibility-questionnaires.

Strengths	Improvements
Easy to read	Need for a pocket card of summary for using the protocol
Clear goal of the protocol	
Uniformly applicable to all UE injuries (with exception of hand injuries)	Time consuming
Comprehensive information (included all relevant aspects of rehabilitation)	Simpeler abbreviations / shorter protocol
Combination of input from medics and paramedics	Implementation of protocol in patient files

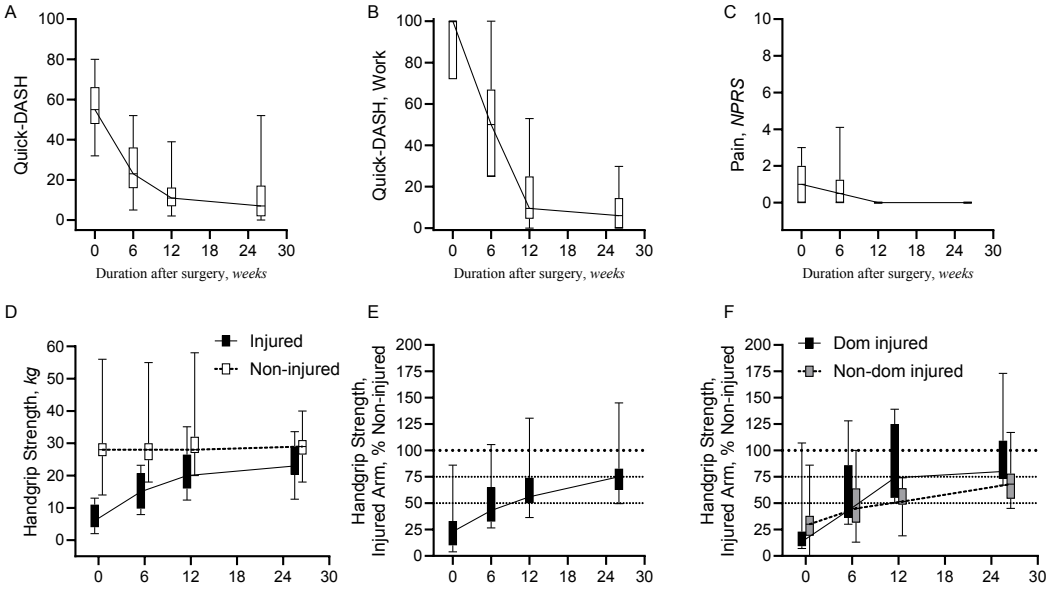

Fig. 6 — PROMs and Handgrip strength. Data is presented as mean and 10th-90th-percentile.

Interpretation of the results

Based on the results, our findings indicate that the protocol is manageable and practical to implement in clinical setting in terms of its application by healthcare professionals. Although completing and reviewing the clinically-related questionnaires took time, which varied depending on the clinical experience of the individual, this was not perceived as disruptive by the participants. The medical jargon was considered manageable by all physicians and paramedics, which made the protocol easy to read. Practitioners appreciated the clear guidelines and the flexibility the protocol allowed to adjust the treatments based on individual patients needs and responses. An effective adjustment could be the implementation of an adaptive protocol, in which achieved milestones are omitted in subsequent assessments. This would progressively shorten the protocol over time, making follow-up assessments more efficient. To facilitate broader adoption across centers, it is essential to shorten the overall protocol, as recommended by 6 out of 10 respondents. Additionally, providing a clear explanation of all abbreviations would enhance usability. Interestingly, while primary clinicians considered the protocol rather lengthy and time-consuming, paramedical staff described it as comprehensive. To support further implementation, it was suggested to offer a one-time training sessions or presentation to address potential questions in advance. Moreover, the development of a pocket card summarizing the protocol's flowchart could aid in quick reference and reduce the time needed for familiarization. Additional recommendations include the automatic monitoring of the flag system of the development of a digital tool to support this process. Furthermore, incorporating patient feedback and experiences during treatment, guided by the protocol, could provide valuable insights and enhance patient-centered care.

Another point of feedback was the terminology used. The variability in language, for example about load bearing, complicates clinical-decision making and leads to diverse therapeutic approaches. Load bearing is not specifically defined for the upper extremity in

this context and is dependent on the advice given by specialists and physiotherapists. The variance in language complicates the clinical decision-making process, leading to the application of numerous therapeutic approaches. A standardized terminology/ protocol would facilitate consistent patient guidance and prevent any confusion during the rehabilitation process, consequently leading to optimal recovery and quicker reintegration into daily routines. With this protocol, we aimed to take a first step in the right direction. It is important to keep these considerations in mind for future adaptations to further improve the protocol for rehabilitation.

Clinically, prolonged immobilization was standard, but recent trends favor shorter immobilization for fractures[18–21]. A study on the immobilization of non-displaced distal radius fractures demonstrated that a shorter immobilization period of one week, compared to the current 4-5 weeks, results in higher patient satisfaction and improved functional outcomes[22]. In our cohort, functional recovery shows significant progress in light daily activities within the first six weeks, and in more complex activities (strength, range of motion, etc.) within three months. Only one complication was observed. While still underpowered to support any clinical claims, clinical data is comparable or better than reported in literature[17,23,24], and complications[25-27], contributing to the previously available evidence of a clinical benefit or shorter, individualized rehabilitation.

Future research must evaluate this (adapted) protocol in a controlled setting and appropriately powered on relevant parameters; this study is currently ongoing. The observed variability in outcomes (e.g. 30% did not achieve PASS-scores) requires further investigation towards differential efficacy between patients and further need for assessing and implementing relevant effect-modifiers. In line with this suggestion, previous papers have called for the need to assess the appropriate load and utilization of the affected arm[9,25].

Limitations of the study

The most important limitation of the protocol is the lengthiness and complex terminology associated with various components within the protocol, a concern also highlighted by the physicians. Simplifying the protocol could enhance its manageability, potentially facilitating its integration into diverse healthcare settings and contributing to broader accessibility and utilization in clinical practice. Additionally, a limitation of the study is the uneven distribution between the number of DRF and PHF cases. As a result, it is not possible to draw conclusions about PHF. Furthermore, no power analysis was conducted, as this is a feasibility study; therefore, no statements can be made regarding the complication rate in our population.

CONCLUSIONS

To our knowledge, this is the first performance based protocol for operatively treated UE fractures focusing on performance based rehabilitation. Unlike other protocols, this one serves as a flexible guideline, allowing for adaptations based on individual patient factors. The positive findings of the qualitative results from this feasibility study suggest that it is safe and feasible in practice according to our findings for at least DRF. A standardized protocol would facilitate consistent patient guidance and prevent confusion during the rehabilitation process. The PERFoRM protocol provides this standardized assessment of load bearing capacity, performance and individualization in rehabilitation, serving as a functional step in this process. Future research will also explore the protocol's applicability to a broader patient population as suggested by the practitioners in hope to create a broadly accepted performance based rehabilitation protocol.

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