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Case Report

Treatment of wrist stiffness through posture orthosis and active exercise: A case report

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ABSTRACT

Introduction: Wrist fractures, particularly the distal radius, can result in significant stiffness and hand dysfunction if not mobilized early. The variable immobilization period post-fracture depends on fracture type, location, stability, and surgical intervention. Inadequate early mobilization typically leads to structured stiffness, influenced by patient health, injury mechanism, joint surface involvement, associated tissue injuries, and patient motivation.

Case presentation: A 64-year-old female in good health suffered a distal radius fracture, treated with open reduction and internal fixation. A modified treatment plan, including custom orthosis and active wrist exercises, was initiated after the standard immobilization phase to enhance the range of motion while accommodating the patient's daily activities.

Clinical discussion: The patient underwent 15 evaluations of active range of motion (AROM) using a goniometer, guided by the American Society of Hand Therapists. A Tissue Composition Analysis (TCA) was performed to guide the orthosis-treatment choice. Despite consistent improvement shown in AROM, it was inconclusive whether the modified treatment contributed significantly beyond the standard approach.

Conclusions: While the patient's AROM improved, the treatment's effect on this single case cannot definitively confirm the efficacy of the modified approach. A more extensive study is necessary to evaluate the conservative treatment strategy's validity for such fractures in high-demand patients, considering the biomechanical complexity of the injury and the patient's professional needs.

Introduction

Wrist fractures, the most common of which is the fracture of the distal radius, if not mobilized early, can lead to the formation of wrist stiffness, resulting in hand dysfunction [1]. The period of immobilization for this type of fracture is very variable and depends on: the type of fracture, the location, stability, and the type of surgical intervention. The formation of post-traumatic and/or post-surgical

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edema and scar tissue leads to the physiological modification of the connective tissue around the joint [2]; consequently, if the wrist is not mobilized early, it will easily lead to the inevitable formation of structured stiffness [3,4]. Many associated factors such as: the patient's general health conditions, the fracture mechanism, whether or not the joint surface is involved, injuries to other tissues, and the patient's motivation can be factors that will affect the final result [5]. Most patients are able to recover a functional range of motion within 3–6 months following the trauma [6,7], while a minority are unable to achieve such a goal despite treatments, which are often represented by mobilization exercises, stretching, strengthening, and physiotherapy [8–12]. In these cases, the use of mobilization orthoses can be useful for joint recovery. As widely described in the literature, these braces must be worn for several hours a day, depending on the type of stiffness and orthosis, static progressive or dynamic [13,14]. However, the disadvantages of using these braces are related to factors such as the same prolonged wearing time, which must be longer if the stiffness is more structured, up to reaching 6–12 h a day [15,16]. Other criticisms of the use of braces are related to the pain they can generate [17] and the risks of damage to the articular cartilage due to prolonged compression caused by traction [18]. Moreover, prolonged use of the orthoses drastically reduces the possibility of using the hand with possible repercussions on functional performance. For these reasons, patient compliance could be altered with treatment failure [17]. Other therapeutic possibilities are represented by plaster valves for wrist posture in flexion or extension, these can be easily modified to adapt to progress in the recovery of the range of motion [19], moreover, they have a very low cost compared to plastic braces. In this case, too, the functionality of the hand is partially affected, and the patient might find some difficulty in removing the valves for hand hygiene and exercises to be performed at home. In the most extreme cases of stiffness, serial casts can be employed, which have a significant impact on the patient's daily life, both in terms of the weight of the cast and the inability to drive and difficulties in personal and work management [20–24]. For the reasons listed above, we tried to use a system of braces, associated with active mobilization exercises, that the patient had to perform mainly at home, with weekly checks by the therapist. The goal of the treatment was to provide the patient with a comfortable and quick-to-wear orthosis that would allow for tension in the tissue in its elastic zone, associated with therapeutic exercises of active mobilization to create further mechanical stretching. The frequent repetition of the gesture was supposed to maintain as much as possible the stretching of the retracted tissue, creating sufficient mechanical demand for tissue remodeling to occur.

Case presentations

The patient is a 64-year-old woman with generally good health and no previous upper limb injuries. On August 14, 2023, following a fall, she sustained a trauma to her right wrist. She visited the emergency department of the holiday location on the same day. Radiographic examinations diagnosed a fracture of the distal radius epiphysis of the right wrist. The therapeutic indication provided by the physician was for an open reduction and internal fixation surgery to address the fracture. Pending surgery, the limb was immobilized using a brace encompassing the wrist and elbow joints.

The patient returned to her place of residence and, on August 16, attended the emergency department of hand surgery, where a second medical consultation confirmed the initial diagnosis and scheduled the surgery.

On August 28, she underwent surgical reduction and synthesis with a Medartis plate and screws, employing a modified Henry incision technique, which was sutured using Nylon 4.0. Post-operation, the wrist was immobilized in a cast for 20 days, during which digit mobilization was authorized and the limb was to be kept elevated to manage edema.

Following the immobilization period, the patient was referred to the hand rehabilitation facility process.

She was taken into care on September 22, 2023, by a physiotherapist specialized in hand rehabilitation with 20 years of experience.

The second phase of treatment, which began on November 28, 2023, was overseen by another experienced therapist with 24 years of expertise (Fig. 1).

The X-ray images depict the right forearm in lateral and anteroposterior (AP) views, showing the outcome following open reduction and internal fixation of a distal radius fracture. Orthopedic hardware, including plates and screws, is observed in situ, demonstrating the current state of skeletal alignment post-operatively. The "D" markers indicate the side of the body as the right (dexter). These images serve as a vital follow-up to evaluate the proper placement of the fixation device and the initial healing process of the fractured

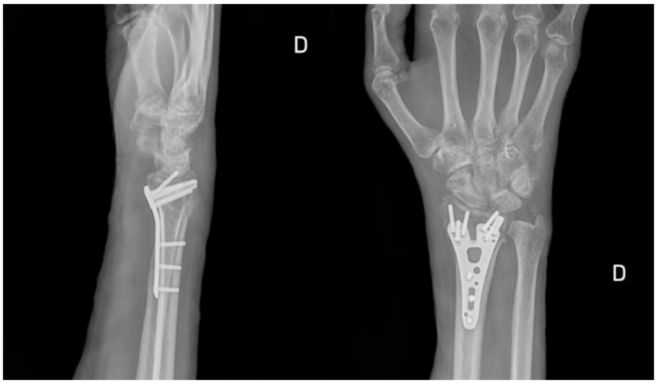


Fig. 1. Post-surgical radiographic assessment of distal radius fracture.

bone.

Clinical findings

The patient experienced a fall leading to a distal radius fracture in her right wrist, which was initially treated with open reduction and internal fixation.

Following surgery, immobilization of the wrist in a cast was advised for 20 days, allowing finger mobilization and limb elevation for edema management.

Rehabilitation began post immobilization, emphasizing active mobilization exercises and the use of orthoses to address wrist stiffness.

A total of 15 comprehensive evaluations of active range of motion (AROM) were conducted using a large joint analog goniometer. This assessment adhered to the guidelines set forth by the American Society of Hand Therapists, employing dorsal measurements for flexion movements and volar measurements for extension. The proximal arm of the goniometer was aligned along the radius, while the distal arm followed the third metacarpal.

The data collected were documented in Table 1.

To accurately quantify the tissue type being treated and to better guide treatment selection, the therapist conducted an initial assessment using the Tissue Composition Analysis (TCA) technique, as proposed by Brand. The decision on the type of orthosis-treatment to be applied subsequently referenced the decision-making hierarchy proposed by Flowers, based on the TCA data. The TCA assessment followed Brand's guidelines, utilizing a digital dynamometer set to gram scale, a soft Velcro strap connected to a non-extensible nylon wire, all attached to the dynamometer to apply load and derive the stress-strain curve. An analog goniometer, positioned dorsally or volarly depending on the motion being assessed as described by the American Society of Hand Therapists, was used for angle measurement during the test (Fig. 2).

For the accurate execution of the test, the strap was placed distally at the wrist's center of rotation, careful to avoid overlaying the metacarpophalangeal joints of the long fingers.

A second operator supported the goniometer, recording angular data at each step of force application.

The initial force was set at 100*g*, increased by 100 g every 3 s up to a maximum of 800 g.

The data were recorded on an Excel sheet from which the stress-strain curve was extrapolated (Fig. 3).

Observation of the graph revealed that the curve quickly became more vertical, indicating tissue with reduced elasticity and thus less prone to stretching. Given the nature of the curve and referring to Flowers' decision-making hierarchy [25], the ideal treatment would be the use of a static progressive orthosis over an extended period.

From the data presented in Table 1, a Cartesian graph was created, displaying the curve of range improvement over the months of treatment (Fig. 4).

Treatment

During the initial session, a custom orthosis was crafted for fracture protection and instructions were given for active wrist exercises. These exercises involved both flexion and extension postures, assisted by the contralateral hand, maintained for 1 min and repeated three times for each movement. This was followed by active flexion and extension movements using a tenodesis wrist-finger scheme. The described exercise session was to be repeated at home every 2–3 h, morning and evening.

In the first phase of treatment, the patient was seen once a week for rehabilitative sessions, and from November 28th, she was also evaluated weekly for 12 weeks.

After a month of standard treatment, the rehabilitative project was modified by incorporating two static orthoses for posture in maximum flexion and maximum extension of the wrist. The dual purpose of these orthoses was to establish a postural system in both

Table 1
Progression of active range of motion (AROM).

Time point	Flexion AROM (degrees)	Extension AROM (degrees)
T1	20	30
T2	20	35
T3	20	40
T4	18	44
T5	20	50
T6	24	50
T7	24	48
T8	28	52
T9	32	58
T10	32	54
T11	38	58
T12	44	60
T13	38	60
T14	42	60
T15	52	62

Fig. 2. Tissue compliance assessment using a digital dynamometer.

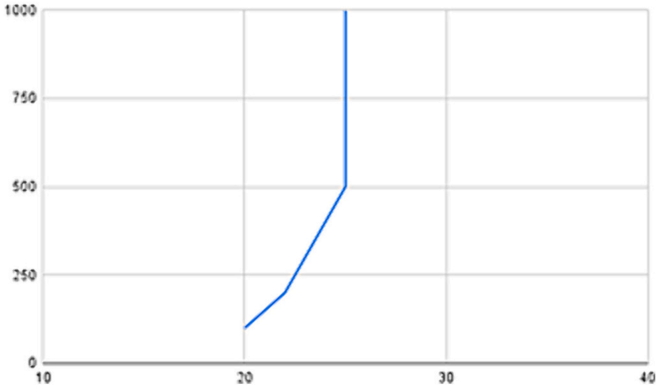


Fig. 3. Stress-strain curve of wrist tissue.

flexion and extension positions and to serve as a reference point for initiating active exercises. As with the previous treatment, the patient was required to repeat the exercises at home every 2 h, but the treatment session was structured differently: the first part was dedicated to maintaining the wrist in either flexion or extension, wearing the orthosis designed for the specific movement. This position was to be held for 10 min, after which the second part of the exercise began, consisting of a series of active movements in the same direction as the posture, attempting to detach the back or palm of the hand from the orthosis. Theoretically, this work aimed to elongate the retracted tissue during the postural phase, with further elongation occurring through active exercises. The repeated stretching solicitation aimed to modify the tissue in response to the new mechanical demands imposed by the posture and exercise. The underlying rationale described here attempts to substitute dynamic or static progressive orthoses for the treatment of wrist stiffness

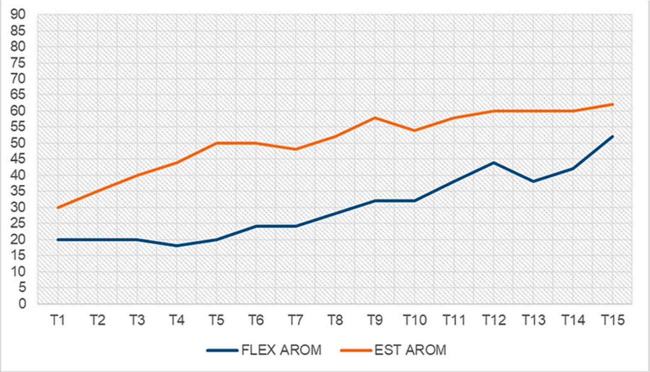


Fig. 4. Trajectory of wrist flexion and extension recovery post-treatment.

following a distal radius fracture.

To continually maintain maximal tissue elongation before active exercises, the orthoses were adjusted by increasing the degrees of flexion and/or extension whenever the space between the hand and the orthosis increased. An increase in this space was indicative of an improvement in the range of motion.

Observation of the graph revealed that the curve quickly became more vertical, indicating tissue with reduced elasticity and thus less prone to stretching. Given the nature of the curve and referring to Flowers' decision-making hierarchy, the ideal treatment would be the use of a static progressive orthosis over an extended period.

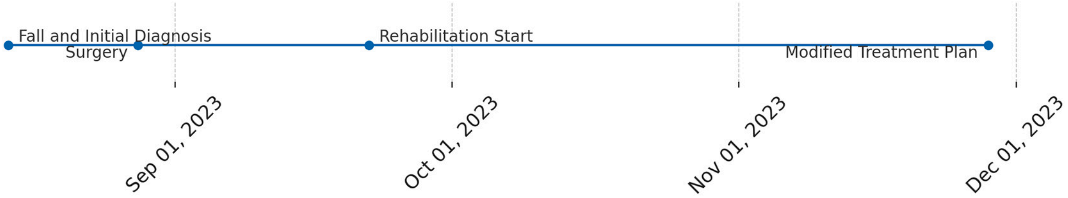
From the data presented in Table 1, a Cartesian graph was created, displaying the curve of range improvement over the months of treatment (Fig. 4).

The figure shows a clinical setting where a digital dynamometer is used to measure the compliance and resistance of wrist tissues. A healthcare professional stabilizes the patient's forearm and applies a controlled force with the dynamometer's probe to assess the tissue's mechanical properties under stress. This procedure is crucial for determining the extent of the wrist's range of motion post-injury or surgery and for customizing the rehabilitation protocol to the patient's current functional capacity.

The graph illustrates the stress-strain relationship for the wrist tissue of a patient undergoing rehabilitation post-fracture. The X-axis represents the strain (deformation) in percentage, and the Y-axis corresponds to the stress (force) applied in grams. The steep vertical rise indicates a low elasticity threshold, suggesting that the tissue demonstrates a limited propensity for elongation under applied stress. This type of curve is instrumental in deciding the course of treatment, especially when considering the application of static progressive orthoses for improving wrist mobility.

This line chart represents the progressive improvement in the active range of motion (AROM) for wrist flexion (blue line) and extension (orange line) over a series of 15 time points (T1 through T15). Each time point corresponds to a step in the patient's rehabilitation journey after a wrist injury, indicating gradual increments in mobility. The trend lines reflect the patient's recovery trajectory, with flexion and extension AROM values measured in degrees, showcasing the effectiveness of the rehabilitative interventions over time. This case study adheres to the SCARE (Surgical Case Report) guidelines for reporting surgical case studies [26,27].

Timeline



Discussion

The primary objectives were to observe a significant improvement in the wrist's range of motion following the rehabilitation project modification. According to Brand's concept of tissue modification through low load prolonged stress, we expected to see this change reflected in the improvement curve. However, based on the data from this singular case, we cannot conclusively state that the project modification led to the anticipated improvement. The curve indeed shows a nearly constant upward progression without notable directional changes after T4, the point at which we transitioned from the standard treatment to the modified approach using posture orthoses and mobilization [20,21,28].

Consequently, it remains unclear whether this progression would have occurred similarly under the standard treatment or if we would have encountered a plateau phase, given that wrist fractures can continue to improve up to 8 months post-surgery.

Treating a single case, while insightful, is insufficient for drawing definitive conclusions. Therefore, a more comprehensive study is warranted to either confirm or refute the foundational premise of the proposed alternative treatment. This study should ideally include a larger sample size to ascertain the effectiveness of the modified treatment approach comprehensively. Additionally, it should consider various patient demographics, fracture types, and severity to understand better how these variables may influence the treatment outcomes. Moreover, a comparative analysis between traditional rehabilitation techniques and the proposed method could shed light on specific benefits or limitations inherent to each approach.

Incorporating a longitudinal study design could also provide valuable insights into the long-term efficacy and sustainability of treatment gains, addressing whether improvements obtained through the modified protocol are maintained over time compared to the standard treatment. Finally, patient-reported outcomes, such as pain levels, functional status, and quality of life, alongside clinical measurements, would offer a holistic view of the treatment impact, ensuring that the rehabilitative strategies align with patient-centric goals and lead to meaningful improvements in their daily lives [29–33].

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Author contributions

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Consent

Informed consent has been obtained from all individuals included in this study.

CRediT authorship contribution statement

Paolo Boccolari: Conceptualization. **Mario Lando:** Supervision. **Lucia Zingarello:** Supervision. **Leonardo Monzani Vecchi:** Validation. **Roberto Tedeschi:** Writing – original draft. **Danilo Donati:** Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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