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Effectiveness of the graded motor imagery to improve hand function in patients with distal radius fracture: A randomized controlled trial

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ABSTRACT

Study Design: Single-blinded randomized controlled trial.

Introduction: Pain management is essential in the early stages of the rehabilitation of distal radius fractures (DRFx). Pain intensity at the acute stage is considered important for determining the individual recovery process, given that higher pain intensity and persistent pain duration negatively affect the function and cortical activity of pain response. Graded motor imagery (GMI) and its components are recent pain management strategies, established on a neuroscience basis.

Purpose of the Study: To investigate the effectiveness of GMI in hand function in patients with DRFx.

Methods: Thirty-six participants were randomly allocated to either GMI ($n = 17$; 52.59 [9.8] years) or control ($n = 19$; 47.16 [10.5] years) groups. The GMI group received imagery treatment in addition to traditional rehabilitation, and the control group received traditional rehabilitation for 8 weeks. The assessments included pain at rest and during activity using the visual analog scale, wrist and forearm active range of motion (ROM) with universal goniometer, grip strength with the hydraulic dynamometer (Jamar; Bolingbrook, IL), and upper extremity functional status using the Disability of the Arm, Shoulder and Hand Questionnaire, and the Michigan Hand Questionnaire. Assessments were performed twice at baseline and at the end of the eighth week.

Results: The GMI group showed greater improvement in pain intensity (during rest, 2.24; activity, 6.18 points), wrist ROM (flexion, –40.59; extension, –45.59; radial deviation, –25.59; and ulnar deviation, –26.77 points) and forearm ROM (supination, –43.82 points), and functional status (Disability of the Arm, Shoulder and Hand Questionnaire, 38.00; Michigan Hand Questionnaire, –32.53 points) when compared with the control group (for all, $P < .05$).

Conclusion: The cortical model of pathological pain suggests new strategies established on a neuroscience basis. These strategies aim to normalize the cortical proprioceptive representation and reduce pain. One of these recent strategies, GMI appears to provide beneficial effects to control pain, improve grip strength, and increase upper extremity functions in patients with DRFx.

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Introduction

Distal radius fractures (DRFx) are one of the most common types of fractures and account for approximately 15% of all fractures in middle-aged women and men.^{1–4} Rehabilitation from DRFx may be

complicated due to challenges associated with prolonged recovery times, discomfort, pain, and decreased mobility.⁵ Common complaints after DRFx include weakness, pain, and stiffness.^{5,6} Pain and edema are commonly seen at the early stages of DRFx, associated with soft tissue problems.^{4,7}

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Conflict of interests: All named authors hereby declare that they have no conflicts of interest to disclose.

Ethical approval: All participants gave written informed consent to participants in the captioned study, and the research was approved by the Hacettepe University Ethics Committee (GO 14/06-06).

Clinical trial registration number is NCT02838446.

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Pain is one of the major risk factors inhibiting recovery, thereby resulting in poor functional outcomes in patients with DRFx.^{4,8} The pain intensity score during the acute stage postinjury determines the patient's profile for rehabilitation and recovery.⁴ Therefore, pain control at the early stages of rehabilitation is considered to be important for reducing the patient's long-term disability level.⁹ Implementing pain management strategies in the DRFx rehabilitation program after injury may improve functional outcomes.^{4,10}

According to recent evidence-based pain control theories, the neuromatrix paradigm codes pain characteristics according to cognitive, emotional, and sensorial dimensions.¹¹ Understanding the underlying mechanisms of the paradigm offers specific rehabilitation strategies that address cognitive, emotional, and sensory aspects of pain.^{11,12} Graded motor imagery (GMI) is a relatively new approach in pain management.^{13,14} GMI aims to organize cortical activation gradually and reduce cortical disinhibition, thereby preventing transition from an acute to a chronic pain state.¹³⁻¹⁶ However, the underlying mechanisms of GMI are not yet fully understood. GMI uses 3 sequential strategies including left/right discrimination, explicit motor imagery, and mirror therapy. These stages are designed to optimize sensory-motor processing and gradually engage the cortical motor networks without triggering the protective pain response.^{15,17}

Chronic pain conditions such as phantom limb pain, chronic low back pain, and complex regional pain syndrome type 1 (CRPS1) are associated with reorganization of the primary somatosensory cortex.^{18,19} GMI has recently been used in the treatment of chronic pain in various orthopedic and neurologic conditions.^{13,17,20} Few randomized controlled trials exist that demonstrate the effectiveness of GMI on pain or function. A systematic review supported the claim that GMI is effective in the treatment of chronic pain conditions, especially in CRPS.²¹ It has also been shown that GMI can control phantom pain in upper and lower limb amputees.²² As pain is a major obstacle to recovery of motion and function after DRFx, pain management is an important goal throughout the rehabilitation process.^{4,8,9} Although evidence supports the view that GMI is appropriate for chronic pain, as far as we know, there is no study revealing the effectiveness of GMI in pain control in the early phase of rehabilitation. However, many studies have shown that therapy methods including visualization approaches help to reduce pain relief at the early stage.²³⁻²⁵ It was also proposed that motor imagery and motor intention related with proprioception and vision share the same neural mechanisms.^{26,27} Because GMI provided a multitude of visualization approaches, including mirror therapy, motor imagery, and lateralization, we hypothesized that applying visualization approaches at the acute stages may lead to better pain control and functional outcome. Furthermore, GMI is seen as a cost-effective and noninvasive treatment with limited adverse effects and complications.²² To our knowledge, the effectiveness of GMI on pain and functional status in patients with DRFx has not yet been investigated. Thus, the objective of this study was to determine the effectiveness of GMI on pain control and functional status in patients with DRFx. It was hypothesized that GMI may be an effective rehabilitation strategy to control pain and improve upper limb function.

Methods

Selection and description of participants

Thirty-six participants diagnosed with DRFx were included in this study. Patients with unilateral DRFx who were between 18 and 65 years, who had undergone closed fracture reduction or open reduction internal fixation with a volar locking plate after DRFx,

and who had the intellectual capacity to give informed consent for the treatment were included in the study. Patients were excluded from the study for any of the following reasons: If they were unwilling or unable to participate, had bilateral fracture, had intra-articular or unstable DRFx, had associated bone and soft tissue injury, had fractures due to malignancy, had neurologic or rheumatologic diseases, or had insufficient cognitive functioning. All participants were screened for CRPS1 using Budapest criteria by a medical doctor and an experienced physiotherapist (the second author, CA).

Participants were randomly allocated to either the GMI group or the control group using simple randomization technique using sequentially numbered and opaque sealed envelopes. The envelopes containing the paper sheet with the name of the group and a sheet of carbon paper were obscured with aluminum foil, shuffled, then numbered sequentially, and placed in a plastic container, in numerical order, ready to use for the allocation. Envelopes were opened before the treatment. Allocation was performed by the last author (YY) of this study.

The GMI group received traditional rehabilitation and the GMI program, whereas the control group received the traditional rehabilitation program only. Both groups were treated for a period of 8 weeks. All participants performed a home exercise program. Participants in the control and GMI groups attended two, 1-hour-long supervised physiotherapy sessions each week. The appointments were organized to prevent the 2 groups from encountering each other.

Technical assessments

All participants received a written and verbal explanation of the purposes and procedures of the study. If they agreed to participate, they signed the informed consent form, which was approved by the university ethics committee. Treatments were performed by the first author (BD), whereas assessments were completed by the second author (CA), who was blind to the group allocation.

Demographic characteristics regarding gender, age, weight, height, and dominant and injured sides were recorded at the baseline. Participants were instructed not to take any medical treatments providing pain relief such as acupuncture or use any pain medications or substances throughout the study period.

Visual analog scale was used to evaluate pain intensity.²⁸ The scale consists of a standard ruler marked 0 mm on the left and 100 mm on the right. Participants were instructed to place a mark on the line with regard to their pain intensity while resting and during activity. The scale was labeled 0 (no pain) and 10 (the worst pain), and participants were asked the following 2 questions: "What is your pain level while you are not doing any activities with your hand?" and "What is your pain level during activities that require wrist and forearm motion?"

Active range of motion (ROM) measurements regarding wrist flexion, extension, ulnar and radial deviation, and forearm supination and pronation were evaluated with a universal goniometer and recorded in degrees.²⁹

Grip strength was measured in kilograms using a calibrated hand dynamometer (Jamar; Bolingbrook, IL). The measurements were performed as defined by the American Hand Therapist Association.³⁰ The average of 3 measurements was recorded. The unaffected side was tested first, followed by the affected side.

Disability of the Arm, Shoulder and Hand (DASH) is the gold-standard questionnaire used to assess upper extremity function.³¹ The Turkish version was used.³² DASH includes a 30-item self-report questionnaire to assess the upper extremity disability level. Of the 30 questions, 21 are regarding daily life activities, 5 relate to symptoms (pain, activity-related pain, tingling, stiffness,

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