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ORIGINAL ARTICLE

Constraint-Induced Movement Therapy Combined With Conventional Neurorehabilitation Techniques in Chronic Stroke Patients With Plegic Hands: A Case Series

Edward Taub, PhD,[a] Gitendra Uswatte, PhD,[a,d] Mary H. Bowman, OTR/L,[a] Victor W. Mark, MD,[a,b,c] Adriana Delgado, MA,[a] Camille Bryson, PT,[a] David Morris, PhD, PT,[d] Staci Bishop-McKay, BS[a]

From the [a]Department of Psychology, [b]Physical Medicine and Rehabilitation, [c]Neurology, and [d]Physical Therapy, University of Alabama at Birmingham, Birmingham, AL.

Abstract

Objective: To determine whether the combination of Constraint-Induced Movement Therapy (CIMT) and conventional rehabilitation techniques can produce meaningful motor improvement in chronic stroke patients with initially fisted hands.

Design: Case series.

Setting: University hospital outpatient laboratory.

Participants: Consecutive sample (N = 6) >1 year poststroke with plegic hands.

Interventions: Treatment consisted of an initial period of 3 weeks (phase A) when adaptive equipment in the home, orthotics, and splints were employed to improve ability to engage in activities of daily living. This was continued in phase B, when CIMT and selected neurodevelopmental treatment techniques were added.

Main Outcome Measures: Motor Activity Log (MAL), accelerometry, Fugl-Meyer Motor Assessment (F-M).

Results: Patients exhibited a large improvement in spontaneous real-world use of the more-affected arm (mean lower-functioning MAL change = 1.3±0.4 points; $P<.001$; $d' = 3.0$) and a similar pattern of increase in an objective measure of real-world more-affected arm movement (mean change in ratio of more- to less-affected arm accelerometer recordings = 0.12±0.1 points; $P = .016$; $d' = 1.2$). A large improvement in motor status was also recorded (mean F-M change = 5.3±3.3 points; $P = .005$; $d' = 1.6$).

Conclusions: The findings of this pilot study suggest that stroke patients with plegic hands can benefit from CIMT combined with some conventional rehabilitation techniques, even long after brain injury. More research is warranted.

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Contrary to the prevailing beliefs not so long ago about the ineffectiveness of rehabilitation in chronic stroke, Constraint-Induced Movement Therapy (CIMT)[1] has been shown to produce large improvements in everyday use of the more-affected arm when it is administered >1 year after stroke to patients with mild/moderate to moderately severe motor deficits (grade 2−4 motor deficit) (table 1).[2-4] However, up to 40% of stroke survivors are left with more severe motor impairment of the more-affected arm in the chronic phase,[5] resulting in substantial reductions in independence and quality of life.[6] There are currently no proven treatments that improve real-world arm function in chronic stroke patients with plegic hands (grade 5) (see table 1).

Evidence suggests that CIMT works in part by lifting a conditioned suppression of movement or learned nonuse of the more-affected arm.[7,8] In addition, in correlation with the motor improvement that CIMT produces, it has been shown to produce increases in gray matter volume in sensorimotor cortex, more

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anterior motor areas, and hippocampus on both sides of the brain,[9] as well as other neuroplastic brain changes.[10-13]

The patients in the first CIMT study[1] and in the early replications[3,14-16] had upper-extremity motor deficits that could be characterized as mild/moderate (grade 2 according to the categorization scheme employed here) (see table 1). A subsequent multisite randomized clinical trial with a positive outcome[4] employed patients with mild/moderate and moderate motor deficits (grades 2 and 3). The impression therefore has become general that these are the only patients to whom CIMT applies.[17-19] However, in the past, CIMT has been employed with success in patients with moderately severe hand motor deficits (ie, grade 4 patients) in this laboratory[20] and elsewhere.[21] An attempt was made to treat 2 patients with initially fisted hands (ie, grade 5 patients). No success was achieved with the hand, and there was only modest success at shoulder and elbow, which, in any case, did not transfer to the life situation.[20] However, greater success with a subsequent case (Wymore et al, unpublished data, 2002) led to a more positive outlook and provided the impetus for continuing this line of work. In this study, we tested in preliminary fashion whether patients with functionless hands who are >1 year post-injury would show improvements in everyday use of their more-affected arm after rehabilitation that combines CIMT with conventional techniques for regulating tone.

Methods

Participants

Six community residents with stroke (mean age = 56±11y; median chronicity = 2.5y; 1 woman) with severe upper-extremity impairment were enrolled in this study. A total of 23 possible candidates were identified who were listed sequentially in our contact database of individuals requesting CIMT. Six met criteria, consented to participate, and were enrolled in the study. Seventeen did not meet criteria for the following reasons: too high-functioning (5); receptive or expressive aphasia that would limit ability to be tested with the grade 4/5 Motor Activity Log (MAL) (see Outcome Measures) (4); too low-functioning (3); major health issues (2); and too low cognitively to adequately follow test instructions (3). All 6 enrolled patients had undergone conventional rehabilitation therapy in the acute phase. Five had minimal capacity to extend their wrist with no extension at the fingers; 1 had minimal capacity to extend at the wrist and 1 finger. Table 2 presents additional participant characteristics. All subjects met the active range of motion criteria for inclusion in the grade 5 (severe) category[22] (see table 1). The following main exclusion criteria were used: (1) stroke experienced <1 year earlier; (2) bilateral or brain stem stroke; (3) balance or ambulation problems (eg, assistance required for toileting); (4) substantial cognitive deficits (<24 points on the Folstein Mini-Mental State Examination) or aphasia serious enough to prevent valid performance on sample test items during screening; (5) excessive pain, ataxia, or frailty as

List of abbreviations:

ADL activities of daily living
CIMT Constraint-Induced Movement Therapy
F-M Fugl-Meyer Motor Assessment
MAL Motor Activity Log
NDT neurodevelopmental treatment

Table 1 Stratification of severity of impairment: active range of motion and mean MAL score criteria

Impairment	Shoulder (deg)	Elbow (deg)	Wrist (deg)	Fingers (deg)	Thumb (deg)
Grade 2 (MAL<2.5 for AS & HW scales)	Flexion≥45 and abduction≥45	Extension≥20 from a 90-deg flexed starting position	Extension≥20 from a fully flexed starting position	Extension of all MCP and IP (either PIP or DIP) joints≥10*	Extension or abduction of thumb≥10
Grade 3 (MAL<2.5 for AS & HW scales)	Flexion≥45 and abduction≥45	Extension≥20 from a 90-deg flexed starting position	Extension≥10 from a fully flexed starting position	Extension≥10 MCP and IP (either PIP or DIP) joints of at least 2 fingers†	Extension or abduction of thumb≥10
Grade 4 (MAL<2.5 for AS & HW scales)	Flexion≥45 and abduction≥45	Extension≥20 from a 90-deg flexed starting position	Extension≥10 from a fully flexed starting position	Extension of at least 2 fingers>0 and <10†	Extension or abduction of thumb≥10
Grade 5 (LF-MAL<2.5 for AS & HW scales)	At least 1 of the following: Flexion≥30 Abduction≥30 Scaption ≥30	Initiation‡ of both flexion and extension	Must be able to *either* initiate‡ extension of the wrist *or* initiate extension of 1 digit		

NOTE. Each movement must be repeated 3 times in 1min. Grade 6 patients would fall below the minimum grade 5 criteria.
Abbreviations: AS & HW scales, Amount and How Well scales of the MAL; DIP, distal interphalangeal; IP, interphalangeal; LF-MAL, lower-functioning MAL; MCP, metacarpophalangeal; PIP, proximal interphalangeal.
* Informally assessed when picking up and dropping a tennis ball.
† Informally assessed when picking up and dropping a washcloth.
‡ Initiation is defined for the purposes of criteria as minimal movement (ie, below the level that can be measured reliably by a goniometer).