Constraint-Induced Movement Therapy for Severe Upper-Extremity Impairment after Stroke in an Outpatient Rehabilitation Setting: A Case Report

Michelle Ploughman, Jennifer Shears, Lisa Hutchings, and Michelle Osmond

ABSTRACT

Purpose: Laboratory studies confirm that constraint-induced movement therapy (CIMT) improves upper-extremity (UE) function after stroke. Due to strict patient criteria and the intensive resources required, CIMT has been slow to become part of rehabilitation practice. Our purpose was to determine the feasibility and effectiveness of an adapted experimental protocol within an outpatient clinical setting for a patient with moderate to severe UE impairment who did not meet traditional CIMT criteria.

Patient Description: AJ, a 16-year-old male, experienced a left middle cerebral artery ischemic stroke due to carotid artery dissection one year before beginning CIMT. He demonstrated some proximal movement but no wrist or finger extension. He had received intensive rehabilitation for 12 months prior to beginning CIMT.

Intervention: Two occupational therapists and two physiotherapists collaborated to provide CIMT task training for 6 hours daily for 2 weeks. A knitted mitten extending to the elbow restrained the less-involved UE during 90% of waking hours. Tasks were tailored to AJ's interests, with the goal of integrating his affected UE into his behavioural repertoire.

Measures and Outcomes: After 2 weeks of CIMT, AJ improved in all measures (grip and lateral pinch strength, Action Research Arm Test [ARAT], and Box and Block Test) except the Chedoke McMaster Impairment Inventory. Greatest gains were seen at 6 months in the ARAT and Box and Block Test, which coincided with patient and family reports of AJ's using his arm in everyday functional tasks.

Implications: Shared workload, emphasis on relevant functional tasks, and complete family participation likely influenced the success of CIMT. Our findings suggest that the strict CIMT criteria used in previous studies may exclude patients who might benefit from the treatment. Controlled trials should be undertaken to examine the effects of CIMT in patients with moderate to severe UE impairment.

Key Words: forced-use, hemiplegia, physiotherapy, occupational therapy, upper extremity

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RÉSUMÉ

Objectif : Des études confirment que la thérapie par le mouvement (constraint-induced movement therapy [CIMT]) améliore la capacité des extrémités supérieures après un accident vasculaire cérébral. En raison de critères stricts pour le patient et de ressources intensives requises, la thérapie par le mouvement s'est avérée lente à faire partie de la pratique de réadaptation. Notre objectif était de déterminer la réalisabilité et l'efficacité d'un protocole expérimental adapté à un milieu de consultations externes où le patient est atteint d'une incapacité des extrémités supérieures de moyenne à grave qui ne répond pas aux critères traditionnels de thérapie par le mouvement.

Description du patient : AJ, un jeune homme de 16 ans, avait subi un accident ischémique cérébral de l'artère sylvienne, suite à une dissection de l'artère carotide, un an avant le début de la thérapie par le mouvement. Il jouissait du mouvement proximal mais ne manifestait aucune extension du poignet ou des doigts. Il a reçu une réadaptation intensive pendant 12 mois avant le début de la thérapie par le mouvement.

Intervention : Deux ergothérapeutes et deux physiothérapeutes ont collaboré afin de fournir la thérapie par le mouvement six heures par jour, la formation par les tâches pendant deux semaines. Une mitaine en tricot jusqu'au coude restreignait l'extrémité supérieure pendant 90 % des heures de veille. Les tâches ont été personnalisées aux intérêts d'AJ dans le but d'intégrer son extrémité supérieure dans son répertoire de comportements.

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Mesures et résultats: Après deux semaines de thérapie par le mouvement, AJ s'est amélioré dans toutes les mesures (force de saisie et force de pincement latéral, le test du bras recherche-action et le test avec une boîte et des blocs) sauf dans l'inventaire des incapacités de Chedoke McMaster. Les gains les plus marqués ont été constatés après six mois pendant le test du bras action-recherche et le test avec une boîte et des blocs, ce qui coïncidait avec les communications du patient et de la famille d'AJ à l'effet qu'il utilisait son bras tous les jours dans le cadre des tâches fonctionnelles.

Implications: Le partage des tâches, l'accent sur les tâches fonctionnelles pertinentes et la participation de toute la famille ont probablement tous contribué au succès de la thérapie par le mouvement. Nos résultats suggèrent que les critères stricts de la thérapie par le mouvement utilisés lors d'études précédentes peuvent exclure des patients qui pourraient profiter du traitement. Les essais contrôlés devraient être entrepris dans le but d'examiner les effets de la thérapie par le mouvement chez les patients qui ont une incapacité au niveau des extrémités supérieures de moyenne à grave.

Mots clés: usage forcé, hémiplegie, physiothérapie, ergothérapie, extrémité supérieure

INTRODUCTION

Taub was one of the first to describe "learned non-use" in deafferented monkeys. The notion of learned non-use means that patients with hemiplegia have latent or un-optimized recovery that can be unmasked via sufficiently intense rehabilitation approaches.¹ Constraint-induced movement therapy (CIMT) reverses learned non-use of the hemiplegic upper extremity (UE) in people after stroke or head injury.¹⁻⁶ Treatment includes use of a sling and splint to restrain the less-affected UE, combined with 6 hours per day of task-specific training for the affected UE. The task-training component is called "shaping," a process of correcting abnormal movement patterns while gradually increasing task difficulty.^{1,3} Restraint of the less-involved limb paired with 6 daily hours of UE training results in improvement of grasp and release, as measured by the Wolf Motor Function Test, and enhanced incorporation of the affected limb during activities of daily living (ADL) as measured by the Motor Activity Log.^{1,3,5} Moreover, precise imaging techniques such as transcranial magnetic stimulation and functional magnetic resonance imaging (fMRI) have demonstrated that improvement with CIMT is accompanied by activation of otherwise quiet cortical regions adjacent to the ischemic area.⁷

Typically CIMT has been successful in improving function in patients who already have isolated finger and wrist extension.²⁻⁶ Few studies have examined CIMT in more severely affected patients (those with less than the required 10° wrist extension and finger extension).^{8,9} Because of these strict criteria, most people with stroke do not qualify for the treatment,^{10,11} which may partially explain why CIMT has not been incorporated into current practice.¹¹ In one study, only 8 of 187 patients screened fit the criteria to participate in a CIMT trial.¹⁰

Although most would recognize that CIMT would be beneficial for people with stroke, it has not been routinely applied in rehabilitation facilities, mainly because of the resources (time and expertise of therapists) required. In a survey on the application of CIMT, Page et al.¹² found that 68% of people with stroke would not wish to participate in CIMT and were unlikely to comply

with the treatment; 74% of therapists reported that they did not have the resources to apply the intensive UE therapy component, speculating that space limitations and the extraordinary demands on their time would preclude their involvement in CIMT. Others have also discussed these points.^{10,11,13}

Our experience (treating 100 survivors of stroke as outpatients and 70 as inpatients) is that patients and their families have become more knowledgeable about current approaches to rehabilitation and demand experimental treatments such as CIMT. However, the clinical reality of high workloads and short inpatient stays that emphasize independence in mobility places rehabilitation of the UE at a lower priority and discourages CIMT intervention. Later in the rehabilitation process, when more people are ambulant, improving arm function takes on higher priority, and this may be the time when it is most feasible to implement CIMT. In this case report, we describe (1) how the CIMT protocol has been implemented in our facility and (2) a patient with a typical clinical presentation for our facility (no finger or wrist extension but some proximal shoulder and elbow movement) and the measured outcomes.

CASE DESCRIPTION: AJ

AJ, a 16-year-old high school student, experienced sudden onset of right-sided weakness and expressive aphasia in April 2005. MRI showed carotid artery dissection and partial thrombosis of the internal carotid artery and middle cerebral artery (MCA) on the left. Another MRI 2 days later showed a large evolving infarct of the left MCA territory with mass effect and midline shift. Ten days after stroke, AJ was transferred from acute care to the neurological rehabilitation unit and received daily physical therapy (PT) and occupational therapy (OT) as well as speech therapy, psychology, and recreation. Three weeks after the stroke, AJ was able to walk with a cane and was independent in ADL. Sensation and proprioception were intact throughout the right side, but active, isolated movement of the UE was limited to facilitated flexor movements (Chedoke Impairment Inventory Stage 2; see Table 1). AJ had increased muscle tone of

Table 1 Outcome Measure Scores for Subject

Measure	1 Week Post- Stroke	1 Month Post- Stroke	4 Months Post- Stroke	2 Weeks Pre- CIMT	1 Week Pre- CIMT	1 Day Pre- CIMT	End of CIMT Week 1	End of CIMT Week 2	1 Month Follow- Up	6-Month Follow- Up
CMII Arm	2	3	3	n/a	n/a	3	3	3	3	3
CMII Hand	2	2	2	n/a	n/a	2	2	2	2	2
CMII Leg	4	4	7	n/a	n/a	7	7	7	7	7
CMII Foot	2	2	3	n/a	n/a	3	3	3	3	3
ARAT	n/a	n/a	n/a	n/a	n/a	27	30	30	30	37
Box & Block	n/a	n/a	n/a	n/a	n/a	10	12	12	13	18
Grip strength (kg)	n/a	n/a	n/a	16.8	16.4	17.5	17.7	20.6	18.3	18.0
Lateral pinch strength (kg)	n/a	n/a	n/a	n/a	n/a	3.3	5.5	6.4	6.8	5.8

ARAT = Action Research Arm Test; CIMT = constraint-induced movement therapy; CMII = Chedoke-McMaster Impairment Inventory

the right calf and UE and received *botulinum-A* toxin injections in May 2006 (Modified Ashworth Scale 3; injected muscles were gastrocnemius, tibialis posterior, flexor digitorum, and superficialis) and every five months thereafter.

That same month (4 weeks after stroke), AJ was transferred from the inpatient rehabilitation unit to the outpatient interdisciplinary day hospital and received daily OT and PT. In addition, AJ's family instituted a sensorimotor stimulation programme for his right UE 3 hours per day (hot/cold application, vibration, picking up objects). The family was very concerned that although AJ could pick up some objects and move his shoulder and elbow, he did not incorporate his right UE in everyday activities, even for bilateral tasks (e.g., stabilizing a jar while opening the lid). After researching CIMT on the Internet and speaking to leading researchers in the field, they began a home programme of constraint of the less affected UE using a sling during performance of household tasks, such as ironing and stacking dishes, that continued for two months (July and August). In September, AJ returned to high school and continued to receive outpatient PT and OT four times per week. Despite the most intense intervention we and his family could provide, AJ's hand function did not improve.

In March 2006, 11 months post-stroke, AJ and his family wished to try CIMT and wanted therapists to provide the programme. Therapists responsible for AJ's care decided that CIMT would be reasonable, considering his age and motivation. Consent was obtained from AJ and his parent to participate in CIMT and to collect data and video for research purposes in accordance with standards of the Human Investigations Committee of Memorial University.

The following challenges were identified: (1) CIMT is resource intensive and would take an entire day's time of one PT or one OT staff member, an impossibility given existing caseload demands; (2) AJ had limited UE motor recovery and no finger or wrist extension; and (3) AJ, his family, and therapists reported that he had become proficient at left-handed manipulation, and it was likely that "learned non-use" had occurred.

INTERVENTION

Therapists and the Decision-Making Process

The therapists involved in AJ's rehabilitation recruited two other experienced therapists (one PT and one OT) to investigate the feasibility of providing CIMT. After reviewing the CIMT literature, the CIMT team decided to split the 6 hours of intense task-training into four 90-minute treatment sessions. The therapists and family agreed that interest- and occupation based-tasks would likely optimize carry-over of training into AJ's daily repertoire of activities. Since the OTs were familiar with task analysis and use of skills inventories, AJ and his mother were asked to list activities in which AJ would be interested in participating (see Table 2). The physiotherapists would incorporate strength, alignment, and movement refinement into treatment.

Each therapist had at least 12 years' experience in stroke and brain injury, but none had previously provided CIMT. Responsibilities of therapists, AJ, and his family, were discussed and agreed upon (see Figure 1). The client and his mother had articulated the following goals: (1) to use the right arm more in functional activities, such as eating, and (2) to be able to release objects consistently once grasped. Each identified activity in the skills inventory was broken down into component tasks and was discussed in terms of amount of assistance required and movements to encourage and discourage (e.g., trunk substitution).

AJ predominantly used a UE flexion movement synergy and made multiple attempts to release small objects by flexing his wrist to open his fingers. Movements of the arm were accompanied by scapular elevation and shoulder abduction. The CIMT therapists weighed the issues of degree of trunk and arm compensatory movements and decided to prohibit excessive use of the trunk in reaching tasks but to compromise by allowing wrist flexion to assist finger opening during object release. The patient did not attend school for two weeks during CIMT. The constraint aspect of the training was carried out by the family at home using a

Table 2 Schedule for Week 1 of CIMT

Day	PT 1	OT 1	OT 2	PT 2
Monday	9:00–10:30 a.m. Cactus garden Tennis	10:45 a.m.–12:15 p.m. Make pizza	1:00–2:30 p.m. Guitar Air hockey	2:45–4:15 p.m. Essay on computer for school
Tuesday	2:45–4:15 p.m. Video games Badminton	9:00–10:30 a.m. Playing pool	10:45 a.m.–12:15 p.m. Stir-fry lunch	1:00–2:30 p.m. Floor hockey
Wednesday	9:00–10:30 a.m. Cactus garden Video games	2:45–4:15 p.m. Essay on computer	1:00–2:30 p.m. Guitar Make cookies	10:30 a.m.–12:15 p.m. Chess Bead necklace
Thursday	9:00–10:30 a.m. Video games Badminton	10:45 a.m.–12:15 p.m. Clubhouse sandwich and fries	2:45–4:15 p.m. Painted stained glass	1–1:30 p.m. Computer games Floor hockey
Friday	1:00–2:30 p.m. Badminton Tennis Snakes-and-ladders game	10:30 a.m.–12:15 p.m. Playing pool Video arcade	9:00–10:30 a.m. Guitar Air hockey	2:30–4:15 p.m. Computer games Chess

Figure 1 Outline of the responsibilities of all members of the team providing CIMT.

thumbless mitten¹⁴ every day for 2 weeks, except during toileting and bathing. Constraint was not applied during the task-training component of CIMT.

Tasks

The specific tasks and their components are not detailed in most CIMT studies. However, tasks

trained during CIMT can be divided into two broad categories: rote generic tasks, such as grasping puzzle pieces, marbles, or cones,^{1–3} and functional occupation-based tasks that are meaningful and purposeful for the participant.^{15–17} We used age-appropriate, patient-identified activities, rather than conventional generic activities, to assist the patient in incorporating

the affected arm and hand into his behavioural repertoire.

Tasks were arranged during the day to equally address strength and motor control (see Table 2). Some tasks were identified to develop strength and speed (tennis, badminton), while others aimed at developing coordination and control of grasp (cutting up vegetables, playing video games, playing billiards, playing the guitar). Therapists divided activities amongst themselves, considering both their own ability to assist with particular activities and optimal arrangement of activities throughout the day. For example, one therapist who could play the guitar provided this activity during CIMT. Some tasks required the assistance of custom-designed supports, so these were discussed and consensus obtained. A splint was fabricated for AJ's right forefinger to allow use of this finger during typing (a school essay typed on the computer). AJ also required built-up handles on eating and cooking utensils. We assessed a number of different video-game controllers and video games that would capitalize on AJ's current movement abilities and decided to begin with a controller that senses noise (clapping hands) and operates with a slap (shaped like bongo drums).

Schedule and Treatment Sessions

The therapists met two weeks before beginning the CIMT programme. A schedule was developed for the entire two weeks of CIMT, taking into account therapists' previous commitments and an appropriate mixture of activities (see Table 2). Each 90-minute therapy session focused on actual performance of tasks, with little time spent on education or explanation. The goal was for AJ to use his right hand in function, using as many different types of manipulation and movement as possible. Therapists did provide hands-on and verbal cues during movement execution to modify or support a problematic movement. For example, AJ was reminded not to overuse shoulder elevation when lifting and placing the hand. He also needed stretching of the hand, wrist, and elbow flexors every 20–30 minutes to reduce muscle tone, especially with more intense and competitive activities (e.g., video games). Before, during, and after CIMT, AJ and his family continued a home programme of picking up household objects for 30 minutes per day.

OUTCOME MEASURES

Chedoke-McMaster Impairment Inventory

The Chedoke-McMaster Impairment Inventory (CMII) consists of six items (arm, hand, leg, foot, postural control, and shoulder pain), each of which is scored on a seven-point scale. Estimates of interrater and test-retest reliabilities have been reported to be on the order of 0.85–0.96 and 0.75–0.92 respectively.¹⁸ Moreover, the

convergent construct validity of the CMII is supported to the extent that its impairment items have been shown to display moderate to high correlations—typically between 0.49 and 0.93—with other measures believed to be assessing the same set of impairments.¹⁸ Neither the standard error of measurement (SEM) nor the minimal detectable change (MDC) has been reported for CMII items. All PTs received training (video, manual, and in-service) on its application. The measure was administered by the same therapist throughout the 2-week intervention.

Grip Strength and Lateral Pinch Strength

Maximal grip strength of the paretic UE is a sensitive measure of arm recovery after stroke.¹⁹ Grip strength was measured using the Jamar Hand Dynamometer in kilograms (kg) by the same therapist during the CIMT programme. Lateral pinch strength (kg) was also tested by the same therapist. For both measurements, the patient was tested while sitting, without back support, with the elbow at 90° according to documented guidelines;^{19,20} the mean value of three attempts was recorded. Estimates of interrater and test-retest reliability in hemiparesis have been reported to be 0.88–0.98 and 0.90–0.98 respectively.²¹ Maximal grip strength is correlated with other measures of UE function after stroke (ICC = 0.71–0.87),²² and the SEM is reported to be between 4% and 20% of the group mean.²³ The MDC for maximal grip strength has not been reported. Interrater reliability for lateral pinch strength is high (ICC > 0.87);²⁴ however, test-retest reliability, validity, SEM, and MDC have not been reported.

Action Research Arm Test

The Action Research Arm Test (ARAT) measures the ability to grasp and release various objects, including blocks, spheres, and cylinders of various sizes, as well as to pour water. Nineteen activities are subdivided into grip, grasp, pinch, and gross motor categories, with the maximum score for each task equal to 3 and a total possible score of 57. The ARAT was constructed and scored²⁵ using time limits determined from performance times of healthy elderly adults.²⁶ Interrater and test-retest reliabilities have been estimated to be approximately 0.99,²⁶ and the ARAT has been shown to display moderate to high levels of convergent construct validity²⁷ when used to measure outcome after CIMT.⁶ A within-patient change of 5.7 ARAT points has been reported to be important and detectable.²⁶ The ARAT was administered by the same therapist throughout the case study.

Box and Block Test

The Box and Block Test (BBT) is a timed test that is simple to perform and measures how many 2-cm blocks can be transferred from one compartment to another in

60 seconds. The apparatus was constructed as outlined by Mathowitz et al.,²⁸ and the average of three trials was taken at each testing session. It was administered by the same therapist throughout the study. The BBT has high interrater (ICC = 0.99) and test-retest (ICC = 0.96) reliability in people with stroke and displays moderate to high levels of convergent construct validity (ICC = 0.79–0.95) compared to other measures of UE function after stroke.²⁹ SEM and MDC have not been reported, but MDC is believed to be about 5 to 6 blocks (J. Desrosiers, personal communication).

Patient, Family, and Therapist Interviews

To identify opinions and challenges with CIMT, the therapists, AJ, and his family members were individually asked, at the end of CIMT and at follow-up, "What are your impressions of CIMT?" At the end of each week, AJ and his family were asked to identify amount of use of the constraint (i.e., adherence) and right UE use at home during that week. The responses were documented.

PATIENT OUTCOMES

Motor Recovery

As shown in Table 1, AJ's CMII arm and hand scores were largely stable over the entire course of his rehabilitation, with the exception of an increase of one stage in arm score in the first month following his stroke.

Arm and Hand Strength

The grip-strength findings indicate that the largest change from baseline was found at the completion of the CIMT programme (approximately 4 kg), but grip strength then appeared to have decreased at the follow-up assessments. Lateral pinch strength showed a similar pattern (see Table 1).

Arm and Hand Dexterity

Table 1 shows AJ's scores for the ARAT and BBT. The magnitude of the improvements (3 ARAT points and 2 BBT points) after the CIMT was less than that suggested as the minimal clinically important change (6 and 5 points respectively). The ARAT and BBT scores continued to improve between the 1- and 6-month assessment sessions, however; both improvements were large enough to conclude that the changes from the initial assessment were clinically important (10 ARAT points, 8 BBT points). Qualitatively, the improvement in ARAT performance could be attributed to ability to manipulate objects faster as well as picking up and releasing marbles and ball bearings.

Perceptions of CIMT

Therapist Reports

Therapists indicated that they felt competent in providing CIMT in current practice, although they noted that the programme was resource intensive and required ongoing daily collaboration among therapists, family, and patient. Time was required, outside of actual treatment time, for planning and gathering equipment. Appointment times scheduled for only two weeks made the CIMT easier to fit into the therapists' outpatient caseloads. The therapists reported that AJ's ability to use his hand functionally and to use the limb spontaneously in activities improved in the second week of CIMT.

Patient and Family Reports

Despite trying constraint at home before the therapist-based intervention, AJ and his family reported that AJ was not using his right UE at all before CIMT. Family members were frustrated with continually reminding him to use his right hand even to stabilize a dinner plate. During the CIMT programme, AJ wore the constraint mitten during all waking hours, taking it off only to toilet and shower. The family reported that adherence with the constraint mitten was not an issue for them. Outside of his therapy time, AJ used his affected right hand to do usual chores around the house that he would otherwise have done with his left hand, such as emptying the dishwasher, ironing, and sorting and folding laundry. At 1-month follow-up, AJ reported that he used his left hand for taking notes in school but used his right hand to hold water bottles, zip his jacket, and carry books. His family reported that the most obvious change was that they no longer needed to remind him to use his right arm. At an extended family gathering, AJ spontaneously reached out his right hand to shake hands in greeting. His family also stated that they wished to have CIMT again in 6 months in order to make further gains. At 6-month follow-up, AJ and his family reported that he was using his right hand "all the time." He attended a local gym, was able to set up and use the exercise equipment with both hands, and wiped down equipment with his right hand. Although they would like to see more recovery, AJ and his family were satisfied that AJ used the movement he had functionally. They felt that CIMT was responsible for the spontaneous and functional use of AJ's right UE.

DISCUSSION

Skilled learning induces cortical reorganization of motor-map representations in animals,^{30,31} and repetitive active movement of the UE for 6 weeks has been shown to lead to improvements in arm recovery that are sustained at 5 years.³² Most studies have reported

that more intensive task-training programmes for the UE after stroke lead to better outcomes.^{33,34} However, many patients will use their less affected limb in ADL to achieve independence. Although the ischemic brain may be neuroplastic, the patient may not optimize this opportunity if 1 hour of affected limb training is negated by another 12 hours of unaffected limb dominance. CIMIT and other intensive task-specific training regimens attempt to optimize neuroplasticity processes and reverse learned non-use.^{34,35} In this case report, a person with chronic stroke and minimal UE recovery appeared to benefit from CIMIT combined with an occupation-based training approach (i.e., after the 2-week intervention, the affected limb was used more functionally). Moreover, the treatment can be provided effectively in a rehabilitation outpatient setting with coordination between multiple therapists and patient and family commitment.

Transferring CIMIT from the Laboratory to the Clinic

Despite success with CIMIT in laboratory settings, transfer of CIMIT to the clinic has been slow, with limited acceptance among clinicians.¹² In the recent publication of the EXCITE (Extremity Constraint Induced Therapy Evaluation) clinical trial of CIMIT, Wolf stated that “the extent to which the intensive CIMIT schedule of delivery can be altered and is ultimately cost-effective requires further exploration.”⁵ Many therapists express concern about the extraordinary time and resources required by CIMIT.^{10–13} Concerns have also been raised about the intensity of the programme, especially for patients with comorbidities and those with balance difficulties.¹²

Some studies have attempted to modify the CIMIT programme, eliminating¹² or reducing³⁶ the 6 daily hours of task training. However, there are indications that these strategies may diminish results. Pierce et al.³⁶ attempted to integrate CIMIT into standard care with 1 hour of PT and OT every other day along with forced use at home, but found limited benefit. Others¹³ have reported that 6 hours per day of task training is superior to 3 hours per day. Our findings support this conclusion, as AJ had already undergone daily PT and OT with home constraint with no measurable or anecdotal change in ability to use the affected UE. Only when the entire CIMIT was applied were there both subjective improvements (according to therapist and family/patient reports) and objective improvements (based on ARAT, grip and lateral pinch strength, and BBT scores) in function. This does not mean that the complete CIMIT programme was simple to provide. Despite sharing the workload, therapists reported that the demands of providing CIMIT were high, and delivering the programme required substantial planning and preparation outside of direct patient contact time.

AJ appeared to have reached a “plateau” in recovery in the months before beginning CIMIT. Even with high-dose

intervention, his family and therapists were unable to prevent learned non-use in the presence of compensatory (left-handed) behaviour. Despite improvements in strength (grip and pinch) and dexterity (ARAT and BBT) during and after CIMIT, there was no change in CMII stage. We noted that although AJ used his hand for functional grasp and release following CIMIT, release was achieved by flexing the wrist slightly with thumb abduction. His proficiency, speed, and strength improved, but these improvements were still dominated by flexor synergy. It is likely that AJ already had the capacity to use these movements before CIMIT but was not using them because of his skill in compensatory left-handed activities.

Occupation-Based Training versus Generic Tasks

Our training approach not only included 6 hours of one-on-one UE training but used tasks that were relevant and age-appropriate for the patient. We ensured that training sessions included novel and interesting tasks to optimize attention, and we used tactile and verbal feedback and repetition to facilitate learning. Careful examination of AJ’s interest inventory by both OTs and PTs ensured that all dimensions of tasks were analyzed (range of motion, movement components, subtle finger compensation, and adaptations) and that these relevant tasks were likely to be incorporated into his movement repertoire. In a case report, Blanton and Wolf⁴ described a programme of supervised ADL and occupation-focused tasks during CIMIT; their subject, however, had less impairment of the UE than AJ, and the tasks were supervised rather than actively facilitated. Guillot et al.¹⁵ have suggested that CIMIT programmes using ADL- and occupation-based tasks rather than rote generic exercises ensure task-specific and relevant learning. In a recent study,¹⁶ CIMIT incorporating meaningful daily activities chosen by the individual (including bimanual activities such as meal preparation) resulted in improvements in grip strength and performance on the Wolf Motor Function test that were sustained at 6 months. Using relevant tasks that replicate daily activities seems to improve performance in the long term.³⁷

Our findings suggest that CIMIT has beneficial effects long after the protocol has been completed. In fact, the greatest improvements in reaching and grasping tasks were seen at 6-month follow-up. The minimal clinically important difference for the BBT has not been reported, although stroke therapists report it to be about five to six blocks (J. Desrosiers, personal communication). At 6 months, AJ’s ARAT and BBT scores improved beyond the reported minimal clinically important difference for these measures (6^{26,38} and 5 respectively), suggesting that the changes were real and meaningful. This follow-up testing coincided with family reports that AJ was using his right hand functionally and spontaneously for

everyday activities. Although grip and lateral pinch strength had declined at 6-month follow-up, this was not surprising considering the predominance of function versus strength activities in the training. We suggest that two weeks of CIMIT reversed AJ's learned non-use and that the concomitant repetitive, everyday functional movements actually improved his UE function. In other words, a behavioural change from CIMIT may have improved function.

It appears that intensive ADL- and occupation-based training is a critical component to incorporate the affected limb into daily activities. Generic grasp and reach tasks seem to produce improvements in Wolf Motor Function Test performance in people with severe UE impairment; unfortunately, however, these improvements seem to be short-lived, as there is a drop in amount and quality of use of the limb, measured subjectively by the Motor Activity Log⁸ and a return to pre-CIMIT levels,³⁹ at 6-month follow-up. This suggests that movements practised in therapy were not automatically incorporated into the subjects' behavioural repertoire. Subjects reported that it was simply easier to use the less-affected arm.⁸ Clearly, recovery of function does not necessarily lead to functional limb use.

CIMIT for Patients with Severe UE Impairment

Studies examining the benefit of the standard CIMIT protocol exclude subjects with less than 10° of active wrist extension and finger extension,^{1,2,4,5} with some studies requiring even more active range of motion.⁶ In this case report, we describe CIMIT for a patient with grasp but no isolated wrist or finger extension who would therefore not meet the criteria for CIMIT. This level of UE function is typical of patients in a rehabilitation setting.⁴⁰ The benefits of CIMIT in these more severely affected patients are just beginning to be examined.^{8,9} In a small study examining CIMIT in subjects with only grasp, Bonifer et al.⁹ showed that CIMIT resulted in increased UE movement that was sustained at 1 month. The findings reported here indicate a need to examine the benefits and challenges of providing CIMIT to this patient population.

Patient and Family Commitment and Satisfaction

Using a phenomenological approach, Guillot et al.¹⁵ examined factors influencing success with CIMIT. Personal motivation and an intense desire to increase functional ability were critical components to participation in CIMIT. Participants also believed that neurorehabilitation is a continuum that does not end, and they continually adapted to changing abilities. Participants experienced increased efficiency and effectiveness in ADL during CIMIT and were motivated to continue to improve their functioning. In the case reported here, it appears that AJ was influenced by the strong desire of

his family members to improve his UE function. Their frustration with his level of recovery before CIMIT, their willingness to participate in the programme, and their success in "forcing the use" of his affected hand at home were major factors in the decision to provide CIMIT.

IMPLICATIONS AND FUTURE DIRECTIONS

Quantitative and anecdotal data collected during this case study allowed a detailed examination of the process and practicality of applying CIMIT in an outpatient setting. The CIMIT programme is intensive and uses extensive human resources for the 2 weeks of the protocol. However, the outcomes, especially at 6-month follow-up, suggest that the treatment changed behaviour in the long term. This patient progressed from being entirely left-handed to achieving bilateral function.

Future research should extend the CIMIT criteria to a broader population of patients after stroke. The specific tasks trained should also be examined. Are occupation-based activities superior to generic reaching and grasping tasks in improvement of motor control and carry-over to ADL? The success of the CIMIT protocol in stroke also raises questions about our traditional method of service delivery. Is a 2-week "burst" of therapy more effective than the traditional outpatient schedule (i.e., 1 hour three times per week) in neurorehabilitation?

Although we expect that the numbers of clients appropriate for CIMIT, with the required motivation, are few, we are prepared to provide the programme as needed. In order to facilitate translation of CIMIT from laboratory to practice, providers need to develop comfort with criteria, scheduling, session content, and measurement surrounding CIMIT.

KEY MESSAGES

What Is Already Known on This Subject

CIMIT improves UE function in people with chronic stroke who have some motor recovery; however, the approach is slow to become part of rehabilitation practice.

What This Study Adds

This case report demonstrates that CIMIT can be applied in an outpatient rehabilitation setting using a collaborative functional approach between team members, the stroke survivor, and the family. Furthermore, the treatment benefited a person with less motor recovery than is considered optimal for CIMIT.

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