Original Article

The California Tri-pull Taping Method in the Treatment of Shoulder Subluxation After Stroke: A Randomized Clinical Trial

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Abstract

Background: Shoulder subluxation is a frequent occurrence in individuals following a stroke. Although various methods of treatment are available, none of them address all possible consequences of the subluxation pain, limited range of motion, the subluxation, and decreased functional use of the arm. **Aims:** The purpose of this study was to evaluate the effectiveness of California tri-pull taping (CTPT) method on shoulder subluxation, pain, active shoulder flexion, and upper limb functional recovery after stroke. **Materials and Methods:** This was a randomized control study on 30 participants. All participants received conventional neurorehabilitation 5 days a week over 6 weeks. Half of the participants also received the CTPT. Pre- and post-assessment scores were taken on all participants for the amount of shoulder subluxation, pain, active shoulder flexion, and functional recovery. **Results:** The CTPT method demonstrated a significant reduction of pain in the treatment group from baseline, a significant improvement in active shoulder flexion and a significant improvement in proximal arm function as measured on the proximal subscale on the Fugl-Meyer upper extremity functional Scale but not the distal or total Fugl-Meyer subscales. Shoulder subluxation was not statistically significant. **Conclusions:** The CTPT method is an effective treatment for the hemiplegic subluxed shoulder.

Keywords: Shoulder dislocation, shoulder subluxation, strapping, stroke, taping, treatment outcome, upper extremity

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Introduction

A common secondary musculoskeletal impairment after stroke is the inferior displacement of the humeral head from the glenoid cavity, referred to as inferior shoulder subluxation.[1,2] The rate of shoulder subluxation poststroke varies with the occurrence as high as 81%.[3] The primary cause of shoulder subluxation after stroke is not known although many different reasons have been proposed as contributing to subluxation. These range from compromised muscle activity around the shoulder, especially in the supraspinatus, which reduces the stability of the shoulder joint[4-6] to the effect of loading on the flaccid extremity,[5] as well as increased downward scapular rotation which possibly allows the head of the humerus to sublux inferiorly.[4,6,7]

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Pain may occur in some patients with shoulder subluxation. In a review of the literature Roy[8] found that shoulder pain is reported in patients with hemiplegia between 5% and 84% due to differing definitions of pain and patients selected. Many different factors have been found to contribute to shoulder pain. Hayner[9] examined all reported causes of shoulder pain and suggested that "that if a correlation exists between pain and subluxation, it is the result of the increased risk of trauma from improper handling of the subluxed hemiplegic shoulder and overstretching of tissue, possibly leading to impingement problems and tears." Hayner[9] further suggested that any shoulder pain in the subluxed shoulder needs to be treated so that it does not limit a patient's desire and ability to participate in treatment.

Of the current treatment methods available: Arm and shoulder slings, electrical stimulation, taping, strapping (in some cases the term is used interchangeably with taping), and positioning, none have demonstrated they are fully effective in aligning the head of the humerus into the glenoid fossa, reducing pain, allowing for functional use of the arm, and maintaining symmetry of upper extremities (UEs). There have been limited reports of taping the shoulder to treat shoulder subluxation in the poststroke population[9-12] and limited additional reports of taping to address the pain.[12-15] The taping method, placement of the tape, and type of tape all vary greatly in these studies.

Hayner[9] developed the California tri-pull taping (CTPT) method and found in a quasi-experimental single subject ABA design study that participants showed significant improvement in subluxation, active range of motion, activity of daily living skills (ADL's), and that the participants found the tape to be comfortable, but there was no significant reduction in pain. Chatterjee *et al*.[12] also found similar results in a ten subject AB design study. There was a significant reduction in shoulder subluxation and pain and a significant improvement in active shoulder flexion and upper limb motor recovery. Hayner's[9] CTPT method used three pieces of rigid tape, with a firm upward pull, to support the hemiplegic subluxed shoulder. All three pieces were applied from 1.5 inches below the deltoid tuberosity up to mid spine of the scapula (posterior), two inches above the glenoid fossa (middle) and 1.5 inches above the clavicle (anterior).

The purpose of this study was to evaluate the effectiveness of the CTPT method in a randomized control study on post-stroke participants with shoulder subluxation over a longer intervention period than reported in Hayner's[9] initial findings on this method (6 weeks, not 3 weeks). Specifically, this study evaluated if the CTPT method reduced shoulder subluxation, reduced pain, increased active shoulder flexion (AFLXN), and improved functional arm use.

Materials and Methods

Research design

The study was an interrupted time series, randomized control, single subject AB design across 30 participants [Figure 1]. Baseline (a) consisted of measuring the amount of shoulder subluxation, pain, AFLXN and UE motor ability of the affected arm. Intervention (b) entailed applying shoulder tape every Monday, Wednesday, and Friday for 6 weeks. The study was approved by the ethical review board of Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (MMIPR) in Mullana, India. All participants received informed consent.

Participant recruitment

Participants were patients who suffered from a stroke and had both shoulder subluxation and pain. Participants were recruited over a 10-month period from the Maharishi Markandeshwar University, Mullana-Ambala, India, and the outpatient Department of MMIPR, Mullana, India. The inclusion criteria were (1) acute stroke, (2) a minimum of 5 mm (0.2 in) shoulder subluxation in the involved UE, (3) shoulder pain, (4) Mini Mental Status Examination (MMSE) score >23, (5) age 35–70 years, and (6) Brunstrom's stage 1 and 2. The participant exclusion criteria were (1) MMSE score <23, (2) other musculoskeletal disorder of the affected UE, (3) history of trauma to the affected UE, (4) hyper or hypo sensitivity disorders, (5) skin allergy to tape, (6) Brunstorm's stage 3 and 4, (7) patients with a neurological disorder other than stroke, (8) uncooperative, and (9) individuals who were unable to follow commands.

Instruments and outcome measures

Participants were evaluated for accromio humeral distance (AHD), using a digital vernier caliper. The measurement was taken in centimeters (cm) from the inferior aspect of the acromion to the superior aspect of the humeral head. The patient was seated with the effected UE in a nonsupported position. In a systematic review Paci *et al*.[16] reported that the caliper method was reliable. The *r* value of the caliper method was 0.93[17] and intraclass correlation coefficient (ICC) ranged between 0.81–0.95[18] and 0.53.[19] This method also achieved a differing validity scores from 0.023 to 0.747.[18,20]

A 10 cm visual analog scale (VAS) was used to measure pain at rest with one indicating no pain and ten indicating extreme pain. Although VAS has been found to be reliable and valid for patella femoral pain,[21] there

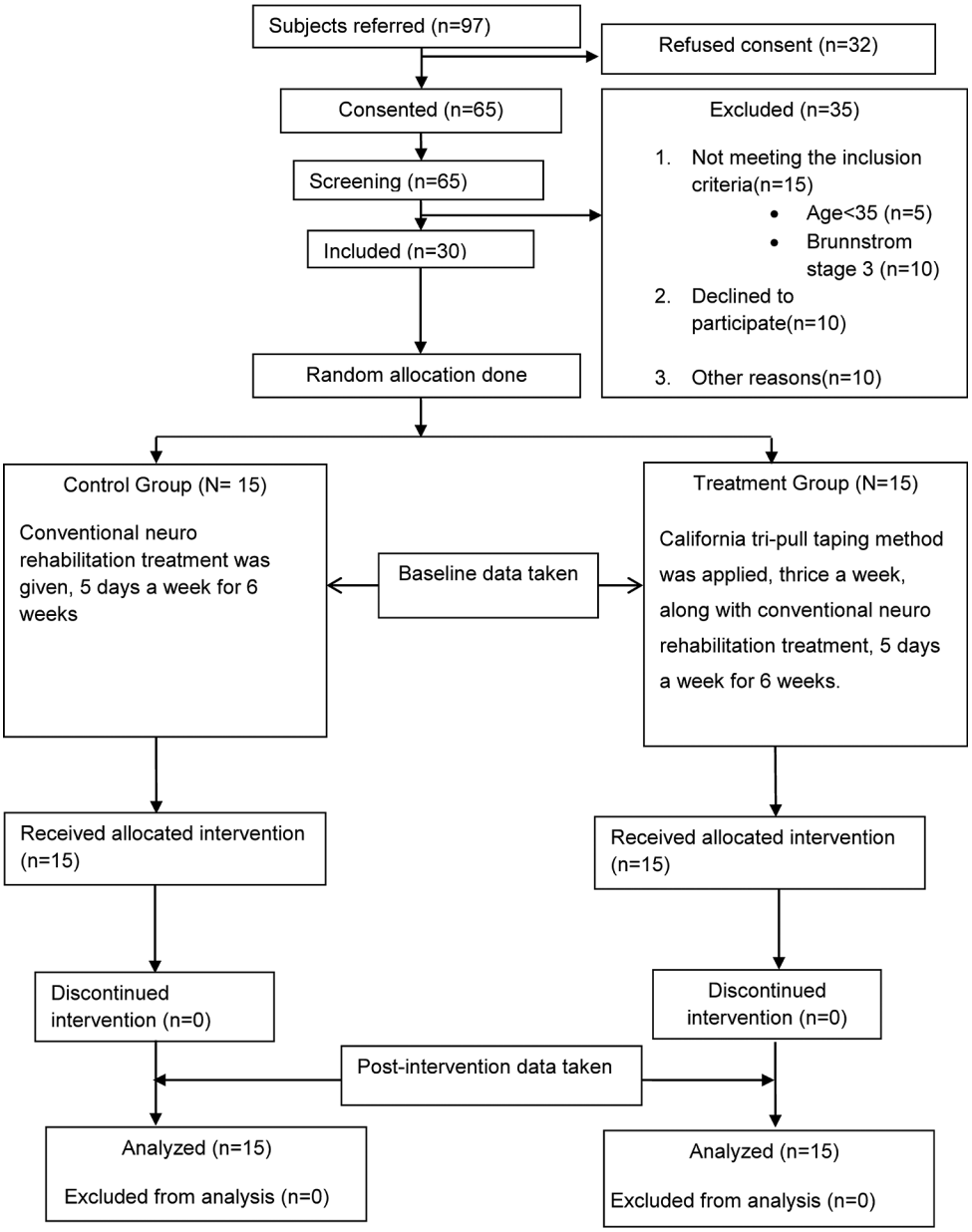

Figure 1: Flow chart of the participants and study

have been no reports on reliability for using VAS for shoulder pain.

The active shoulder flexion (AFLXN) range of motion was assessed using goniometric measurement. AFLXN was assessed with the participants in supine for a more accurate measure. MacDermid *et al.*[22] measured the reliability of passive lateral rotation of the shoulder using a goniometer and found that intratester ICC's (0.88–0.93) and intertester ICC's (0.80–0.85) were high.

The motor functioning of the UE was assessed by using the Fugl-Meyer assessment (FMA) for the UE. The FMA is a stroke-specific, performance-based impairment index with the maximum score for the UE motor domain being 66. For the UE motor domain on the FMA, we used the total score (FMA-T) and then divided the scale into two further components, proximal (FMA-P) and distal (FMA-D) depending on the motor performance being evaluated. Sanford and Moreland[23] evaluated the interrater reliability of the FMA (FMA-T) assessment for testing motor performance in patients following stroke on 12 patients. They found excellent interrater reliability on the UE FMA (FMA-T) domain with the ICC 0.92.

Intervention

A sample of 30 patients completed the study. Half of the sample (n = 15) were randomly assigned to the control group (neuro-rehabilitation only) and the other half (n = 15) were randomly assigned to the

treatment group (neuro-rehabilitation and shoulder taping). See Figure 1 for flow chart of the participants. Intervention was given by the lead researcher who was trained in the taping method. The following baseline measurements and before taping, participants with hair on their shoulder region were asked to shave. Two types of tape were applied, a self-adhesive 1.5" cotton undercover tape and a 1" rigid strapping tape. To approximate the humeral head into the glenoid cavity participants were instructed to place their affected arm on a supporting table. Three pieces of rigid strapping tape were applied on top of the cotton undercover tape, used to protect the skin. The undercover tape was applied first without any pull (a) from 1.5 inches below the deltoid tuberosity to two inches above the glenoid fossa (middle), (b) from 1.5 inches below the deltoid tuberosity to 1.5 inches above the mid spine of scapula (posterior), and (c) from 1.5 inches below the deltoid tuberosity, over the coracoid process to 1.5 inches above the clavicle (anterior). These three cotton strips were then covered in the same location with the rigid strapping tape but with a firm upward pull, allowing the tape to "ripple." Two final pieces of tape were placed on each end to further secure the tape[9] [Figure 2, Taping Steps]. Every Monday, Wednesday, and Friday the tape was removed, and new tape applied over six consecutive weeks.

All the participants received conventional neuro-rehabilitation. The conventional neuro-rehabilitation treatment included an active and passive range of motion, neuromuscular re-education, tone normalization, weight bearing exercises of the UE, functional reach, grasp, hold and release activities and ADL activities. Every participant received conventional neuro-rehabilitation for 45 min a day, 5 days a week for 6 weeks.

Data collection

Data were collected by a therapist blind to the assignment (treatment or control) of each participant and not involved in the taping. Baseline measurements were collected before intervention for all participants at the start of the 6 weeks period and postintervention data was collected at the end of the 6 weeks period. During both data collection periods, the following data were collected: Amount of subluxation, AFLXN, pain, and UE motor performance.

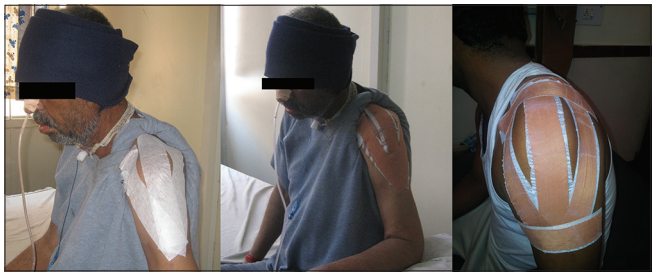

Figure 2: Taping sequence: Sequence of California tri-pull shoulder taping method taken by the first author

Statistical study

Data analysis was first completed using SPSS version 22.0 software (manufactured by IBM Corp.) with 95% confidence level. A paired *t*-test was used to compare pre and postmean values of all variables (AHD, VAS, AFLXN, and FMA). An independent *t*-test was used to compare the pretest and posttest score changes between Groups A and B, respectively for AHD, VAS, AFLXN and FMA-P, FMA-D and FMA-T variables. Following this, we recruited a research firm, Hanover Research in Arlington, Virginia, to assist us to further critically evaluate our data and to add scrutiny to the findings as noted below. These analyses were conducted using Stata version 12.1 (manufactured by StataCorp) with 95% confidence level.

To ensure that the patients were indeed randomly assigned to the treatment and control groups, a series of independent *t*-tests were conducted to compare the groups on participant demographics and outcome measures at pretest. As Table 1 shows, the differences between the treatment group and control group on all variables examined were small and not statistically significant (all $P > 0.45$). This indicates that the two groups, on average, shared similar characteristics and that the random assignment was successful.

The treatment group and control group were then compared on the outcome measures at posttest in regression models. For each outcome, a model both with and without covariates was completed as a further robustness check. Overall, the results did not change after the inclusion of covariates. Therefore, the results are discussed regarding the mean differences between the treatment and control group as the mean differences are equal to regression coefficients in the models without the covariates.

Further, a difference-in-differences method was employed. The difference-in-differences method takes into account the baseline level of the outcomes at pretest. It measured the change in outcomes of patients in the treatment group over time relative to the change in outcomes of participants in the control group over the same period. Therefore, this method examined whether the improvement of desirable outcomes (or reduction of undesirable outcomes) from pretest to posttest among the treatment group was significantly larger than the improvement (reduction) among the control group. Table 2 presents the regression results. Figure 3 illustrates the means of all outcome variables at pre- and post- test by group.

Table 1: Differences between the treatment and control group at pretest

	Treatment group (Group B)		Control group (Group A)		Difference	*P*
	Mean	*n*	Mean	n	Treat-control	
Observable characteristics						
Age	63.20	15	62.80	15	0.40	0.802
Female	0.40	15	0.47	15	−0.07	0.724
Male	0.60	15	0.53	15	0.07	0.724
Left side shoulder	0.67	15	0.60	15	0.07	0.716
Right side shoulder	0.33	15	0.40	15	−0.07	0.716
MMSE	27.13	15	27.40	15	−0.27	0.587
Pretest outcomes						
ADH	2.56	15	2.81	15	−0.25	0.468
VAS	7.20	15	7.67	15	−0.47	0.504
AFLXN	12.07	15	11.80	15	0.27	0.722
FMA-proximal	8.47	15	8.40	15	0.07	0.894
FMA-distal	2.73	15	2.60	15	0.13	0.456
FMA-total	11.20	15	11.00	15	0.20	0.692

Independent *t*-test compared the groups on characteristics and outcome measures at pretest. The differences between the treatment and control group on all variables were not statistically significant (all *P*>0.45) indicating that random assignment was successful. ADH = Acromio humeral distance, VAS = Visual analog scale, AFLXN = Active shoulder flexion, FMA = Fugl-meyer assessment, MMSE = Mini mental status examination

Table 2: Difference-in-differences analysis results

	AHD	VAS	AFLXN	FMA-P	FMA-D	FMA-T
Treatment-control difference at pretest	−0.247 (0.335)	−0.467 (0.689)	0.267 (0.741)	0.067 (0.494)	0.133 (0.176)	0.200 (0.500)
Pre- and post-test difference in control group	−0.067 (0.333)	−0.200 (0.659)	7.333 (0.996)**	2.667 (0.537)**	0.733 (0.228)**	3.400 (0.559)**
Difference in differences (β)	−0.636 (0.449)	−2.333 (1.025)*	4.867 (1.915)*	1.733 (0.845)*	−0.067 (0.304)	1.667 (0.918)
Observations	60	60	60	60	60	60
R^2	0.167	0.286	0.679	0.585	0.279	0.625

*P<0.05, **P<0.01. The regression coefficients of "difference in differences (β)" indicate the treatment effect. The models were re-run to include covariates (i.e., age, gender, affected side, and MMSE) and the treatment effects did not change.Thus, the results without covariates are reported here. Numbers in parentheses are standard errors. ADH = Acromio humeral distance, VAS = Visual analog scale, AFLXN = Active shoulder flexion, FMA = Fugl-meyer assessment, MMSE = Mini mental status examination

Results

Participant demographics

Thirty participants were enrolled in this study. Half of the participants (*n* = 15) were randomly assigned to the control group and the other half (*n* = 15) to the treatment group. See Table 3 for gender, affected extremity, age, MMSE score, and duration since stroke.

Shoulder subluxation/accromio humeral distance

At posttest, the treatment group (M = 1.857, standard deviation [SD] =0.738) had significantly shorter AHD than the control group (M = 2.740, SD = 0.893). However, the difference-in-differences analysis revealed that although CTPT reduced participants' AHD in the treatment group, the treatment effect was not statistically significant (β = −0.636). In other words, after accounting for the baseline level at pretest, the reduction in the treatment group was not statistically larger than the reduction in the control group.

Pain

At posttest, the patients in the treatment group (M = 4.667, SD = 2.410) reported significantly less pain at rest than the control group (M = 7.467, SD = 1.684). That is, the patients in the treatment group reported, on average, 2.80 points less pain than the patients in the control group. Further analysis using the difference-in-differences approach also demonstrated a statistically significant treatment effect (β = −2.333).

Active shoulder flexion

At posttest, the level of AFLXN was significantly higher among the patients in the treatment group (M = 24.267, SD = 6.006) than in the control group (M = 19.133, SD = 3.270). The difference-in-differences test demonstrated a statistically significant treatment effect (β =4.867) indicating that the taping improved the amount of active shoulder flexion significantly more than those who only received conventional treatment.

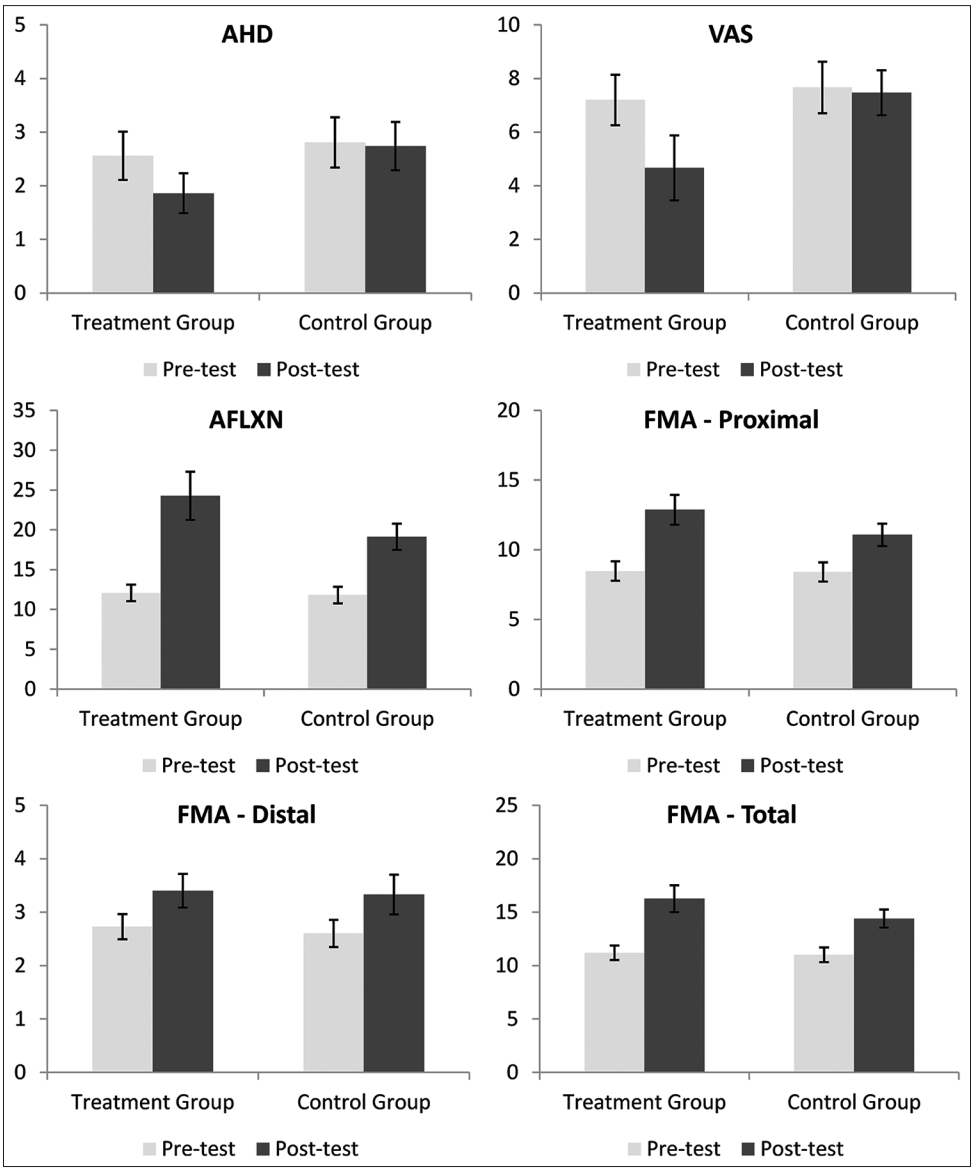

Figure 3: Outcome variables: Means of all outcome variables at pre- and post- test by group. The error bars represent 95% confidence intervals. Abbreviations as follows: Acromio humeral distance (ADH); visual analog scale (VAS); active shoulder flexion (AFLXN); Fugl-Meyer assessment proximal (FMA–proximal); Fugl-Meyer assessment-distal (FMA–distal); Fugl-Meyer assessment-total score (FMA–total)

Table 3: Participant demographics

Variable	Control	Treatment
Age[a]	62.8±4.5	63.2±4.0
Gender		
Male %[b]	8 (53.3)	9 (60)
Female %[b]	7 (46.7)	6 (40)
Affected side		
Left side %[b]	6 (40)	5 (33.3)
Right side %[b]	9 (60)	10 (66.7)
MMSE score[a]	27.40±1.352	27.13±1.302
Duration of stroke (days)[a]	24.467±7.396	21.33±8.682

[a]Data are mean±SD, [b]Data recorded in number and percentage for each group. MMSE = Mini mental status examination, SD = Standard deviation

Upper extremity motor function

There were significant and positive differences between the treatment and control group at posttest on the FMA proximal and total subscale. Specifically, the patients in the treatment group (M = 12.867, SD = 2.134) scored, on average, 1.80 points higher on the FMA proximal subscale than the patients in the control group at posttest (M = 11.067, SD = 1.580). The treatment group also had a higher total score, which may primarily be driven by the differences on the proximal subscale. The follow-up difference-in-differences test revealed that the treatment effect was only significant for the FMA

proximal subscale (β =1.733) but not the total (β =1.667) or distal subscale (β = −0.067).

Discussion

The results indicate that the CTPT method benefited participants poststoke with subluxation and shoulder pain in improving AFLXN, reducing pain, and improving proximal motor function.

The improvement in AFLXN was speculated by Hayner[9] to be due to a reduction in pain and subluxation since no participants received therapy during the study. In this study, all the participants received conventional neuro-rehabilitation and therefore the treatment group, which had a significant reduction in pain but no significant reduction in subluxation appears to have improved AFLXN due to the reduced pain. The significant reduction in pain is speculated to be a result of both the protection of the joint (provided by the tape) from further trauma during active and passive movement, ambulation and ADLs, as well as the re-approximation of the head of the humerus into the glenoid fossa (from the upward pull of the tape) allowing for more normal movement patterns.

It is assumed that improvement in the UE motor functioning of a patient would correlate to functional improvements in ADL's. Shelton *et al*.[24] found that the FMA and functional independence measures (FIM) (a broad measure of functional ability), have excellent correlation in individuals who recently had a stroke (r = 0.63) suggesting that the significant improvement in distal motor control would result in improved functional ability. In addition, Bernspång *et al*.[25] looked at a sample of 109 recent stroke survivors and found that the FMA effectively distinguished between three levels of self-care. They concluded that motor impairment strongly predicts self-care ability after a stroke.

It is interesting to note that the additional look at the change in proximal and distal motor function found that only the proximal motor function improved. Since motor function and strength tends to recover initially in the proximal arm before the distal arm, this finding shadows the typical poststroke client's motor recovery.

There was not a significant reduction in subluxation following the CTPT method but the result, although not significant, was trending in the expected direction of reduced subluxation. This result may be due to the wide spread of treatment group patients' scores at the pretest. A future study looking at radiologic measurements for any amount of reduction in subluxation may achieve more accurate data than measurement using a caliper.

Strengths and limitations

The strengths of this study were the randomization of the participants, allowing for stronger evidence on the effectiveness of the CTPT method, as well as the larger number of participants in this study over the prior two studies available in the literature. Limitations of this study are (a) the participants were limited to those that were flaccid or demonstrated early spasticity (stage 2 of Brunnstrom's stages of stroke recovery), (b) there was no follow-up to determine if the effects demonstrated were maintained, (c) the conventional therapy, received by all participants in the study, could not be controlled for and may have varied among the participants and d) there was not a specific measure of ADL functional performance though the FMA has excellent correlation to the FIM.[24]

Conclusions

Findings of this study indicate that the CTPT method reduces pain, improves active shoulder flexion, and improves distal UE functional ability. This appears to be a promising early adjunctive treatment for clients who have suffered a stroke and demonstrate pain in a subluxed shoulder to increase shoulder flexion, motor ability, and ultimately functional ability. Moreover importantly, this taping method allows the patients to participate in all active UE exercises as well as all ADL's.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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