
Management of Post Stroke Pain

Robert Teasell MD, Norine Foley MSc, Sanjit K. Bhogal MSc, Katherine Salter BA

Key Points

Further research is needed before conclusions regarding positioning of the hemiplegic shoulder can be made.

There is limited evidence that shoulder slings influence clinical outcomes.

Strapping the hemiplegic shoulder does not appear to improve upper limb function, but may reduce pain.

Aggressive range of motion exercises (i.e. pullies) results in a markedly increased incidence of painful shoulder; a gentler range of motion program is preferred. Adding ultrasound treatments is not helpful while NSAIDs may be helpful.

Functional electrical stimulation may not help with recovery of hemiplegic shoulder.

Deinnervation of the subscapularis muscle may reduce shoulder pain and improve passive range of motion, more so than deinervation of the pectoralis major muscle.

The Evidence-Based Review of Stroke Rehabilitation (EBRSR) reviews current practices in stroke rehabilitation.

Contacts:

Dr. Robert Teasell
801 Commissioners
Road East

London, Ontario,
Canada

N6C 5J1

Phone:
519.685.4000

Web:
www.ebrsr.com

Email:
Robert.teasell@sjhc.london.on.ca

Last updated August 2011

Table of Contents

Key Points	1
Management of Pain Post Stroke.....	3
1.1 Positioning of the Hemiplegic Shoulder.....	3
1.2 Slings and Other Aids	4
1.3 Strapping the Hemiplegic Shoulder	6
1.4 Active Therapies in the Hemiplegic Shoulder.....	8
1.5 Electrical Stimulation in the Hemiplegic Shoulder.....	11
1.6 Surgery as Treatment for Muscle Imbalance	17
1.7 Botulinum Toxin Injections as Treatment for HSP	18
1.8 Steroid Injections as Treatment for HSP	20
1.9 Aromatherapy/Acupressure Treatment for Shoulder Pain	23
1.10 Massage Therapy	23
1.11 Subscapular Nerve Block for the Treatment for Shoulder Pain.....	24
1.12 Summary of the Management of Hemiplegic Shoulder	25
2.0 Treatment of Chronic Regional Pain Syndrome-Type 1 (CRPS-1).....	26
2.1 Pharmacological Treatment of CRPS-1.....	27
2.2 Mirror Imagery as a Treatment for CRPS	29
2.3 Controlled Passive Range of Motion Exercises for the Prevention of CRPS-1	31
2.4 Calcitonin for the Prevention of CRPS.....	31
3.0 Treatment of Central Pain Post Stroke	32
References.....	38

Management of Pain Post Stroke

This chapter will review the evidence for the management of three types of pain:

1. Painful Hemiplegic Shoulder
2. Reflex Sympathetic Dystrophy
3. Central Post Pain State

1.1 Positioning of the Hemiplegic Shoulder

The muscles around the hemiplegic shoulder are often paralyzed, initially with flaccid tone and later with associated spasticity. Careful positioning of the shoulder serves to minimize subluxation and later contractures as well as possibly promote recovery, while poor positioning may adversely affect symmetry, balance and body image. As cited by Gilmore et al. (2004), Davies (2000) suggests that through careful and correct positioning, the development of shoulder pain can be prevented. Bender and McKenna (2001) have noted that a primary goal of early stroke management is to prevent the development of hypertonicity (Johnstone 1992) and to

discourage inefficient patterns (Bobath 1990). Bender and McKenna (2001) noted that the “*recommended position for the upper limb is towards abduction, external rotation and flexion of the shoulder,*” however, from Carr and Kenny (1992) review, Bender and McKenna cite that “most popular theories failed to yield consensus for exact degrees of the positioning.”

A recent meta-analysis (Borisova & Bohannon 2009), which included the results from 5 RCT, representing 126 subjects reported that shoulder positioning programs were not effective in preventing or reducing the loss of shoulder external rotation range of motion. Interventions assessed in the 5 trials included both positioning and stretching programs. In order to prevent contraction, the authors speculated that the duration of stretching may have been insufficient. While 2 hours of stretch was provided in the 2 trials that assessed this form of treatment, the authors speculated that at least 6 hours of stretching a day was required to prevent contracture formation in the soleus muscle of children with cerebral palsy. The authors also suggest that the treatment may have been initiated too late following stroke to be effective.

Table 1. Positioning of the Shoulder in Stroke Patients

Author, Year Country PEDro Score	Methods	Outcomes
Dean et al. 2000 Australia 5 (RCT)	23 patients were randomized to receive an experimental therapy or to a control group. Subjects in both groups participated in a multidisciplinary rehabilitation program and participated in active training of reaching and manipulation tasks. The experimental group received prolonged positioning to the affected shoulder each day, five days	Changes in active and passive range of motion were not significant between the groups with the level of pain remaining unchanged.

	a week for six days (positioning).	
Ada et al. 2005 Australia 6 (RCT)	36 stroke patients were randomized to an intervention or a control condition. Patients in the experimental group received two, 30-minute sessions of sustained shoulder positioning. Patients in both groups received 10 minutes of shoulder exercises and routine upper limb care. The treatment was provided for 4 weeks. Assessments of contracture were taken at weeks 2 and 6 after stroke.	Positioning the shoulder in maximal external rotation (position 1) significantly reduced the development of contractures, compared to the control group. In position 2 (where patients sat with the affected arm resting on a table with the shoulder at 90°, for 30 minutes daily), did not prevent the development of contractures.
DeJong et al. 2006 Netherlands 6 RCT	19 patients with stroke onset no greater than 12 weeks post stroke with severe arm paresis were randomized to receive routine inpatient rehabilitation (n=10) or rehabilitation + a prescribed positioning procedure for 5 weeks, twice daily for a ½ hour (n=9). The arm was positioned with as much shoulder abduction, shoulder external rotation, elbow extension and supination of the forearm as the patient could endure. Passive range of motion, Ashworth scale scores, Pain (yes/no) Fugl-Meyer Assessment scores and BI scores were assessed at baseline, 5 and 10 weeks following treatment.	At 5 weeks, there was a loss of passive range of motion in both groups, although the losses were less pronounced in the experimental group for 3/5 measurements--shoulder external rotation (-19 vs.-18, p=0.37), shoulder flexion (-23 vs. -29, p=0.29), shoulder abduction (-5.3 vs. -23, p=0.042), elbow extension (0.6 vs. -4, p=0.84), forearm supination (-11 vs. -3, p=0.69). There were no significant differences between the groups on any of the other outcomes. No statistical tests were carried out at week 10 due to dropouts.

Conclusions Regarding Positioning of the Hemiplegic Shoulder

There is consensus (Level 3) opinion that proper positioning of the hemiplegic shoulder helps to avoid subluxation. However, there is conflicting (Level 4) evidence that prolonged positioning does not influence active and passive range of motion or level of pain.

Further research is needed before conclusions regarding positioning of the hemiplegic shoulder can be made.

1.2 Slings and Other Aids

Arm slings are often used in the initial stages following a stroke to support the affected arm. However, their use is controversial and they can have

disadvantages in that they encourage flexor synergies, inhibit arm swing, contribute to contracture formation and decrease body image causing the patient to further avoid using that arm. However, a sling remains the best method of supporting the flaccid hemiplegic arm while the patient is standing or transferring. Ada et al (2005) conducted a systematic Cochrane review evaluating the benefit of shoulder slings and supports, and concluded that there is insufficient evidence that these devices reduce or prevent shoulder subluxation following a stroke. The review included only four RCTs (Ancliffe et al. 1992, Griffin et al. 2003 [unpublished data], Hanger et al. 2000 and Hurd et al. 1974). The results are presented in Table 2.

Table 2. Results from Systematic Review (Ada et al. 2005)

Outcome	Studies Included & Intervention	Peto Odds ratio (95% CI) or Weighted Mean Difference (WMD) (95% CI)
Proportion of patients with pain at follow up	Hurd et al. 1974 – hemisling	OR 8.7 (1.1, 67.1) (Favours no slings)
Number of days pain was delayed with treatment	Ancliffe et al. 1992 -strapping Griffin et al. 2003	WMD 14 days (9.7, 17.8) (Favours slings)
Pain scores on VAS (10 cm scale)	Hanger et al. 2000 – strapping	WMD 0.83 (-1.46, 3.12) (No difference)
Motor Assessment sub scores (0-18)	Hanger et al 2000. -strapping	WMD 0.8 (-1.5, 3.1) (No difference)
Proportion of patients with contractures	Hurd et al 1974- sling	OR 1.00 (0.1, 9.3) (No difference)
Range of shoulder external rotation at end of follow up	Hanger et al. 2000 - strapping	WMD -1.4 degrees (-10.9, 8.10) (No difference)

As tone returns to the shoulder muscles, the risk of shoulder subluxation decreases and slings can then be withdrawn. Slings tend to hold the limb in a poor position, which may accentuate the adduction and internal rotation posture and may contribute to shortening of tonically

active muscles. The best method to support the shoulder has yet to be determined. In the absence of empirical evidence of their efficacy, many devices are available and in common use, including a variety of slings and lapboards.

Table 3. Slings and Other Aids in Hemiplegic Shoulders

Author, Year Country PEDro Score	Methods	Outcomes
Hurd et al. 1974 USA No Score	14 patients were alternately assigned to be treated with a sling or without a sling, assessed 2 to 3 weeks and 3 to 7 months post stroke.	Of the 7 patients without slings, 5 had no pain, while 2 had little pain. Of the 7 patients treated with slings, 6 had little pain, while 1 had no pain.
Moodie et al. 1986 Canada No Score	Series of radiographs (anterior/posterior view) of 10 patients' affected and unaffected limbs in order to permit comparisons for degree of subluxation and the 5 aids to be evaluated were then applied to the patients' affected arm and an A/P view was taken of each: conventional sling; shoulder roll; Hook-Hemi Harness; arm trough; and plexiglass lap tray.	Shoulder roll and Hook-Hemi Harness did not reduce subluxation to the same extent as the other 3 devices. Subluxation was reduced within 20% of the correct alignment in 8 out of 10 patients when treated with the sling; 6 of the 10 treated with the arm trough, and 7 of the 10 patients treated lap tray. Suggested that the sling, trough, and lap tray reduced the mean subluxation to within .56 cm of normal control while the roll and hook tended to under-correct the subluxation.
Williams et al. 1988	Radiographs were taken of 26 hemiplegic patients with	There was no significant difference in the reduction of inferior subluxation between the two types of shoulder

Canada No Score	subluxated shoulders with two different supports-the Bobath shoulder roll and the Henderson shoulder sling. Radiographs of the unsupported affected shoulder were compared with radiographs of the same shoulder with each support applied. Radiographs of the unaffected shoulder were used as a comparison in determining the amount of subluxation.	supports. However, there were significant differences in subluxation between measurements of the unsupported affected shoulder and the unaffected shoulder and between measurements of the unsupported affected shoulder and the supported affected shoulder using both supportive devices.
Brooke et al. 1991 USA No Score	Three different shoulder supports were applied to 10 patients by their occupational and physical therapists: Harris hemi-sling, the Bobath sling and the arm trough or lapboard.	Harris hemi-sling improved correction of the subluxation with mean vertical distance of 37.8mm vs 38.5mm compared to the uninvolved shoulder while the mean difference between Harris and Bobath sling was 5.5(2.9) mm, in favour of the Harris sling. For horizontal measurement, mean difference between Harris and Bobath slings was 8.3(6.3) mm, in favour of the Harris sling.
Zorowitz et al. 1995 USA No Score	An occupational therapist applied each shoulder support to each of 20 patients in the following order: (1) single-strap hemisling; (2) Rolyan humeral cuff sling; (3) Bobath roll; and (4) Cavalier support.	The single-strap hemisling corrected vertical displacement, while the Rolyan and Bobath roll significantly reduced vertical displacement. The Bobath roll and the Cavalier support produced a significant lateral displacement of the humeral head of the affected shoulder compared with the unaffected shoulder. The Rolyan humeral cuff sling significantly decreased the total subluxation asymmetry.

The majority of the trials assessed used a crossover design whereby patients served as their own control as they tried more than one type of sling for a period of time. In none of these trials was the order of slings randomized. It is also difficult to eliminate the effect of carry-over in this type of design; therefore, it is difficult to formulate conclusion.

Conclusions Regarding Slings in Hemiplegic Shoulder

There is limited (Level 2) evidence that shoulder slings prevent subluxation associated with hemiplegic shoulder pain, although there is also limited (Level 2) evidence that one device or method is no better than another.

There is limited evidence that shoulder slings influence clinical outcomes.

1.3 Strapping the Hemiplegic Shoulder

Strapping the hemiplegic shoulder is used as a method to prevent or reduce the severity of shoulder subluxation and may provide some sensory stimulation. There are three different forms of strapping the hemiplegic shoulder, which have been described previously:

Ancliffe 1992: 5-cm wide lightweight adhesive tape (Fixomull Stretch), *“the first length of tape was applied to the shoulder half way along the length of the clavicle, continued across the deltoid muscle in a diagonal*

direction... the tape was terminated approximately one-quarter of the way of the along the spine of the scapula. A second length of tape was applied in the same direction as the first but 2 cm below. A small length of tape was applied over the shoulder to secure the ends”.

Morin & Bravo 1997: *“A 10 cm-wide Elastoplast adhesive bandage was applied under tension from the forearm under the olecranon laterally to the top of the shoulder. Two other 7.5 cm-wide bandages were applied from the olecranon under the forearm to the forearm to the top of the shoulder, with one passing anteriorly over the clavicle and the other posteriorly covering the spine of the*

scapula. No free space was left between the bandages.”

Hanger et al. 2000: Three lengths of nonstretch Elastoplast Sports tape were used. *“The two main supporting tapes were applied first. Both were applied using a lifting action, starting 5 cm above the elbow, and moving up the arm front and back, crossing at the top of the shoulder. The posterior arm tape was then anchored down past the clavicle whereas the tape from the anterior aspect of the arm came across the shoulder and down past the spine of the scapula. They were both supported at the lower end by a short tape to prevent them peeling off”.*

Table 4. Strapping the Hemiplegic Shoulder

Author, Year Country PEDro Score	Methods	Outcomes
Ancliffe 1992 Australia No Score	A pilot study of 8 patients who were assigned to receive strapping of the shoulder applied by one physiotherapist and changed every 3 to 4 days as needed to the hemiplegic side or to receive no strapping. Treatment began within 48 hours of admission to hospital.	Patients in the strapping group experienced a significantly longer pain free period than the patients who were not strapped (21 vs. 5.5 days). However, all patients in the strapping group eventually did experience pain. The longest pain-free period was 25 days.
Hanger et al. 2000 New Zealand 7 (RCT)	98 patients were randomized to have their affected shoulder strapped for 6 weeks in addition to standard physiotherapy or to receive standard physiotherapy only 15 days following stroke.	No significant differences were found between groups on measure of pain, range of movement and on functional outcome measures. There was a trend for less pain at 6 weeks and improved functional upper limb function for the strapping group.
Griffin & Bernhardt 2006 Australia 7 (RCT)	33 patients at risk of developing hemiplegic shoulder pain were randomized to therapeutic shoulder (TS) strapping, sham shoulder (SS) strapping or to a no strapping (control) group 10 days post stroke. Lightweight adhesive tape was used and strapping continued for over 4 weeks. Primary outcome was the number of pain free days. Secondary outcomes included range of movement, Motor Assessment	One person in the TS group developed shoulder pain compared to 5 persons in the other 2 groups. Subjects in the TS group reported 26 pain-free days, compared to 19 days for SS subjects and 16 days for subjects in the control group. The difference was statistically significant for the comparison of TS and control group. There were no differences between groups on any of the secondary outcomes.

	scale scores and Modified Ashworth scores.	
Appel et al. 2011 UK 6 (RCT)	14 patients with mild to moderate hemiparesis following an acute stroke were randomized to receive a program of shoulder strapping in addition to inpatient rehabilitation or to rehabilitation only. One of 5 strapping techniques was used depending on the patient. The strapping was maintained for 4 weeks (and changed every 3 days). The primary outcome was the Motor Assessment Scale, assessed at baseline and at 1,2,3 and 5 weeks. Additional outcomes were the Fugl-Meyer Assessment (FMA) and the 9-Hole peg Test (9HPT).	From baseline to 5 weeks, patients in the control group gained more MAS points on average compared with the intervention group (9.8 to 15.0 vs. 10.7 to 15.2). Patients in the control group gained more FMA points on average compared with the intervention group (50.7 to 60.4 vs. 51.8 to 60.6). Patients in the intervention group took less time to complete the 9HPT compared with those in the control group (94.8 to 37.8 vs. 63.5 to 30.4). Results of between group tests of significance were not reported.

Conclusions Regarding Strapping the Hemiplegic Shoulder

There is conflicting (Level 4) evidence that strapping the hemiplegic shoulder reduces the development of pain. There is moderate (Level 1b) evidence that strapping does not improve upper limb function or range of motion.

Strapping the hemiplegic shoulder does not appear to improve upper limb function, but may reduce pain.

1.4 Active Therapies in the Hemiplegic Shoulder

The association of spasticity, muscle imbalance and a frozen shoulder with shoulder pain suggests that a therapeutic approach designed to improve range of motion of the hemiplegic shoulder will improve pain.

Table 5. Active Therapies in Hemiplegic Shoulder

Author, Year Country PEDro Score	Methods	Outcomes
Inaba et al. 1972 USA 7 (RCT)	33 patients with hemiplegia who experienced shoulder pain in the range of 0-90 degrees of flexion or abduction of the arm after stroke were treated. Patients were randomly assigned to 1 of 3 groups: Range of motion (ROM) exercises and positioning group; ROM exercises and ultrasound; or ROM exercises and mock ultrasound. All patients received ROM exercises for 4 weeks and given a minimum of 15 treatments.	No significant differences between the groups were observed in measures of ROM.
Kumar et al. 1990 USA 5 (quasi-randomized controlled)	28 patients were assigned to receive a rehabilitation program of range of motion by therapist (ROMT) once a day, 5 days a week; or a rehabilitation program with use of skate board once a day, 5 days a week; or a rehabilitation program with use of	Significant difference in the incidence of pain reported between the groups. Shoulder pain was more common in the overhead pulley (63%) group than in the ROMT group (8%). ROM was significantly reduced in those patients

trial)	overhead pulley once a day, 5 days a week while an inpatient on a stroke rehabilitation unit.	who developed shoulder pain when compared to those who did not develop shoulder pain motion abduction, forward flexion, internal rotation and external rotation. Shoulder subluxation was found in 46% of all patients with no significant difference between treatment groups.
Patridge et al. 1990 UK 5 (RCT)	65 patients were randomized to receive cryotherapy or Bobath therapy daily for five days and then after at the therapist's discretion for a total of four additional weeks and assessed by a blinded investigator.	A greater proportion of patients treated by the Bobath method reported no pain or only occasional pain on exit of the study compared to those treated by the cryotherapy method.
Poduri et al. 1993 USA No Score	Patients with stroke experiencing shoulder pain after completing outpatient therapy were studied. One group of patients received either a nonsteroidal anti-inflammatory drugs (Ibuprofen 400-800g tid, and Sulindac, 150 mg bid.) taken 30 to 60 minutes prior to occupational therapy. A second group of patients received only occupational therapy consisting of range of motion, active assistive and strengthening exercises and activities of daily living training.	A significantly greater proportion of patients receiving the treatment drug prior to therapy experienced pain relief. Flexion, abduction and functional recovery were significantly greater in those patients who were taking the nonsteroidal anti-inflammatory drug before therapy.
Tyson & Chissim 2002 UK 4 (RCT)	22 stroke patients with consequential weakness of the arm instructed to hold the hemiplegic shoulder at: (1) an axilla hold involving shoulder support and (2) a distal hold without shoulder support. Each hold was repeated to obtain three measurements with order of testing randomized.	Mean shoulder flexion for the axilla hold was 115.2 degrees and 97.7 degrees for the distal hold ($p < 0.001$).
Lynch et al. 2005 USA 6 RCT	35 stroke patients with significant upper motor impairment were randomized to a control group (n=16), which received self-range of motion exercises under the supervision of a physiotherapist or to the experimental group (n=19) of continuous passive motion treatments with the use of a device (25 min sessions, 5 days/week until discharge). All patients received rehabilitation therapies for 3.5 hours per day.	There were no between group differences in changed scores between groups on any of the outcome measures assessed (joint stability, Modified Ashworth scale, Fugyl-Meyer (pain and self-care FIM scores).
Gustafson & McKenna 2006 Australia 6 (RCT)	34 patients with upper extremity hemiparesis admitted within 100 days of stroke were randomized to a participated in a programme of two static positional stretches, each held for 20 minutes, once daily or to a control condition where the affected arm was supported when seated in bed. Outcome measures included: pain-free passive range of motion, shoulder pain (Ritchie Articular Index), Motor recovery (Motor Assessment Scale) and functional	There were no significant between group differences reported for any of the outcomes. Over time, all participants reported decreased range of motion, motor recovery and functional independence. The control group reported a decrease in pain while the treatment group reported an increase.

independence (modified BI) measured at hospital admission and discharge.
--

Discussion

Inaba et al. (1972) in a "good" (PEDro = 7) study found no significant differences in the outcomes of patients who received: ROM exercises and positioning, ROM exercises and ultrasound or ROM exercises and mock ultrasound. Kumar et al. (1990) found that overhead pullies caused dramatically higher levels of shoulder pain than more restrained ROM exercises. Although there were no statistically significant differences in change scores between the control and the experimental group, Lynch et al. (2005) reported a trend towards improvement in the area of shoulder joint stability associated with continuous passive motion using the OrthoLogic Danniflex600 shoulder CPM system. A programme of positional static stretches was not only ineffective in reducing loss of range of motion into external rotation, but was also associated with increasing levels of pain (Gustafson & McKenna 2006). Counter to previous research, subjects in this study continued to improve functionally, despite a loss of range of motion and increasing pain, reported by subjects in the treatment group.

Partridge et al. (1990) found that treatments using Bobath therapy resulted in significantly less pain than cryotherapy. The general message that emerges from these three studies is that an active ROM exercise approach is preferable to more passive modalities but an overly aggressive approach (i.e. overhead pullies) resulted in a very high incidence of hemiplegic shoulder pain when compared to a gentler approach.

Conclusions Regarding Active Therapies in the Hemiplegic Shoulder

There is moderate (Level 1b) evidence that aggressive range of motion therapies, using overhead pullies results in increased rates of shoulder pain.

There is moderate (Level 1b) evidence that Bobath therapy for the hemiplegic shoulder is associated with greater pain reduction than passive cryotherapy (application of local cold therapy).

There is moderate (Level 1b) evidence that gentle exercises to improve range of motion are the preferred approach. There is moderate (Level 1b) evidence that adding ultrasound therapy to range of motion exercises does not change outcomes.

There is limited (Level 2) evidence that providing an oral nonsteroidal anti-inflammatory drug leads to less pain, improved range of motion and improved functional recovery in stroke patients with shoulder pain receiving occupational therapy.

There is moderate (Level 1b) evidence that static positional stretches performed daily during rehabilitation are associated with increasing pain and decreasing range of motion.

Aggressive range of motion exercises (i.e. pullies) results in a markedly increased incidence of painful shoulder; a gentler range of motion program is preferred. Adding ultrasound treatments is not helpful while NSAIDs may be helpful.

1.5 Electrical Stimulation in the Hemiplegic Shoulder

Electrical neuromuscular stimulation is a term used to describe the application of electrical current to the skin, or directly into muscle that stimulates motor nerves and muscle fibres resulting in improved contractility and greater muscle bulk. The treatment can be used to improve muscle strength, joint misalignment, muscle tone, sensory deficits and self-reported pain intensity (Price & Pandyan, 2000). Electrical stimulation is typically administered by two methods, functional electrical stimulation (FES) or transcutaneous electrical nerve stimulation (TENS). The distinction that is usually made between these two forms of treatment is that lower intensity, higher frequency stimulation is associated with TENS. It is more commonly used to treat pain. Patients usually describe a *"pins-and-needles sensation."* FES has been described as *"bursts of electrical stimulation applied to the nerves or muscles affected by the stroke, with the goal of strengthening muscle contraction and improving motor control."* (Gresham et al. 1995).

The supraspinatus and posterior deltoid muscles are most likely to be treated as they are important muscles in maintaining the correct alignment of the glenohumeral joint (Paci et al. 2005). Theoretically, FES should help to compensate or facilitate flaccid shoulder muscles, which in turn should reduce the risk of shoulder subluxation. The ideal intensity of treatment is thought to be 6 hours daily, five days a week for 6 weeks. FES is performed at frequencies of between 35 to 50 Hz (Paci et al. 2005).

Price & Pandyan (2001) conducted a systematic review of all forms of electrical stimulation (ES) used in the prevention and treatment of post stroke shoulder pain. The included studies and the results are presented in Tables 6(a) and 6(b). The authors concluded that there was insufficient evidence from which to draw conclusions. There was evidence that FES, in addition to conventional therapy, improves function but is not superior for preventing pain.

Table 6(a). Studies included in the Systematic Review authored by Price & Pandyan (2001)

Study	Intervention	Length of Treatment
Faghri et al. 1994	FES vs. no sham treatment	6 weeks
Leandri et al. 1990	Sham treatment vs. high intensity TENS vs. low intensity TENS	4 weeks
Linn et al. 1999	No sham treatment vs. electrical stimulation (not FES or TENS)	4 weeks
Sonde et al. 1998	No sham treatment vs. low frequency TENS	3 months

Table 6(b). Results From Studies Evaluating Any form of ES in the Treatment and Prevention of Shoulder Pain

Outcome	Significant Result (Y/N)	Odds Ratio* or Weighted (or Standardized) Mean Difference and 95% CI
New cases of shoulder pain	No	0.64 (0.19, 2.14) *
Pain intensity rating change from baseline	No	0.13 (-1.00, 1.25)
Passive humeral lateral rotation	Yes	9.17 (1.43, 16.9)
Motor score change from baseline	No	0.24 (-0.14, 0.62)
Glenohumeral subluxation compared to baseline	Yes	-1.13 (-1.66, -0.60)
Spasticity score change from baseline	No	0.05 (-0.28, 0.371)

Ada & Foongchomcheay (2002) also conducted a meta-analysis to examine the effect of electrical stimulation on shoulder subluxation following stroke. This review included the results from 6 RCTs (Baker & Parker 1986, Faghri et al. 1994, Kobayashi et al. 1999, Linn

et al. 1999, Wang et al. 2000). The results, presented in Table 7 suggest that early treatment following stroke helps to prevent the development of hemiplegic shoulder while later treatment helps to reduce pain, in addition to conventional therapy.

Table 7. Pooled Results from Ada & Foongchomcheay (2002)

Outcome	Intervention	Significant Result (Y/N)	Weighted Mean Difference and 95% CI
Shoulder subluxation (mm)	Early ES + CT* vs. early CT	Yes	6.5 (4.4, 8.6)
Shoulder subluxation (mm)	Late ES + CT vs. Late CT	No	1.9 (-2.3, 6.1)
Function (Bobath assessment chart, Motor assessment scale and Fugl-Meyer) expressed as a percentage	Early ES + CT vs. early CT	Yes	18.6 (0.4, 36.7)
Function (Bobath assessment chart, Motor assessment scale and Fugl-Meyer) expressed as a percentage	Early ES + CT vs. early CT	No	14.4 (-5.4, 34.2)
Pain (range of motion-degrees)	Early ES + CT vs. early CT	No	3.7 (-1.2, 8.6)
Pain (Visual analogue scale-cm)	Late ES + CT vs. Late CT	Yes	1.6 (0.1, 3.0)

* CT= conventional therapy; ES= electrical stimulation

Fourteen studies specifically evaluated the effects of electrical stimulation on the treatment of shoulder pain. (Table 8).

Table 8. Electrical Stimulation in Hemiplegic Shoulder

Author, Year Country PEDro Score	Methods	Outcomes
Baker & Parker 1986 USA 4 RCT	63 patients with a minimum of 5 mm of shoulder subluxation in their involved upper extremity were randomized to a treatment or control group. Patients in the treatment group received neuromuscular electrical stimulation (NMES) for 5 weeks, while patients in the control group used conventional hemi-slings or wheelchair arm supports.	At six weeks, the mean subluxation of the study group was significantly less compared to the control (8.6 vs. 13.3). Three- month radiographs demonstrated that patients in the treatment group had lost an average of 1-2 mm, which had been achieved during the study period. The authors did not demonstrate a causal relationship between subluxation and shoulder pain.
Leandri et al. 1990 Italy 5 (RCT)	60 patients with chronic hemiplegia shoulder pain randomized to one of three groups. Group A received high intensity TENS plus basic physical treatment. Group B received low intensity TENS plus basic physical treatment. Group C received sham intensity TENS plus basic physical treatment.	Significant improvements in passive range of motion (PROM) were recorded for group A but not for the other groups. No between group comparisons were made.
Faghri et al. 1994 USA 4 (RCT)	26 patients were randomized to receive either functional electrical stimulation (FES) in which two flaccid/paralyzed shoulder muscles (supraspinatus and posterior deltoid) were induced to contract repetitively up to 6 hours daily for six days in addition to conventional therapy (FES) or to receive conventional therapy (control).	After treatment, the FES group showed a significant increase in arm function, tone and EMG activity compared to control patients.
Faghri & Rodgers 1997 USA 4 (RCT)	26 patients received conventional physical therapy with 13 patients randomized to the treatment group, which received additional functional neuro-muscular stimulation (FNS) therapy for 6 weeks.	Weekly evaluation of arm and shoulder muscle function (range of motion), tone, and posterior deltoid muscle EMG activity showed significant improvement in the experimental group when compared to the control group over 6 weeks. Advantage of treatment group was maintained 6 weeks after termination of the FNS.
Chantraine et al. 1999 Switzerland 4 (quasi-randomized controlled trial)	115 patients were alternately assigned to receive traditional Bobath treatment in addition to functional electrical stimulation (FES) for 5 weeks or to receive traditional Bobath treatment for 5 weeks.	Significant motor recovery was noted in favour of FES treatment at three months and was maintained at 24 months. Significant reduction also noted in pain in favour of FES treatment at three months and again maintained at 24 months. Significant reduction in shoulder subluxation in favour of FES treatment was noted at three months and maintained 24 months post-treatment.
Kobayshi et al. 1999 Japan 5 (RCT)	17 patients were randomized to receive therapeutic electrical stimulation (TES) for 15 minutes twice a day to either the supraspinatus muscle (group S) or middle deltoid muscle (group D) in conjunction with conventional therapy, or to receive conventional therapy only.	Difference in subluxation in group S, 2.8(3.6) mm and group D, 2.8(2.5) mm was significantly greater than that of the control - 1(2.8) mm under the stress test. The mean abduction force tended to increase in group S and was significantly greater in group D.

Linn et al. 1999 Scotland 6 (RCT)	40 patients were randomly assigned to a control or treatment group. Patients in the treatment group received electrical stimulation (ES) 4 times daily, ranging from 30 minutes in week one to 60 minutes by week 4. Patients in both groups received daily occupational and physical therapy. Treatments lasted for four weeks. Assessments of shoulder subluxation, pain, and motor control. were carried out at 4 and 12 weeks after stroke	The treatment group had significantly less subluxation and pain after the treatment period, but at the end of the follow-up period there were no significant differences between the 2 groups.
Wang et al. 2000 Taiwan 5 (RCT)	32 inpatient and outpatient rehabilitation patients with hemiplegia were assigned to one of two groups based on the duration of hemiplegia: the short and the long duration. Subjects in each group were randomly assigned to either a control subgroup or an experimental subgroup. Subjects in the experimental subgroups were treated in a type A-B-A study design, which consisted of an FES training (A), routine therapy or regular daily activity without FES training (B), and another FES training (A). Each period lasted for 6 wk. FES training program, consisted of five sessions/week.	The experimental subgroup of short duration showed significant improvements in reducing subluxation as indicated by x-ray compared with the control subgroup of short duration after the first FES treatment. The same effect was not shown for the experimental subgroup of long duration. The second FES treatment program only resulted in an insignificant change of shoulder subluxation for both the short- and long-duration subgroups.
Yu et al. 2001 USA No Score	8 patients participated in six weeks of percutaneous intramuscular electric stimulation (per-NMES).	At end of treatment, there was a significant improvement of shoulder subluxation, pain, shoulder pain-free rotation and in FIM scores. Further improvements were noted at the 3 month follow up in subluxation, pain, Fugl-Meyer, shoulder pain-free external rotation and in FIM scores.
Yu et al. 2001 USA 6 (RCT)	10 hemiplegic stroke patients with at least 1 fingerbreadth of glenohumeral subluxation received 3 randomly ordered pairs of neuromuscular stimulation (NMES) to the supraspinatus and posterior deltoid muscles of the subluxated shoulder. The stimulation types were percutaneous-NMES (perc-NMES) and transcutaneous-NMES (trans-NMES). After each stimulation pain was evaluated with the visual analog scale (VAS) and the McGill Pain Questionnaire (MPQ).	Pain scores were significantly lower for perc-NMES than trans-NMES as assessed by the VAS and the MPQ.
Renzenbrink & Ijerman 2004 Netherlands No Score	15 stroke survivors with chronic (> six months) hemiplegia and a therapy-resistant painful shoulder with subluxation were studied. Shoulder subluxation was indicated by at least 1/2 fingerbreadth of glenohumeral separation on palpation. Patients received 6 hours of Percutaneous Neuromuscular electrical stimulation (P-	A significant reduction in pain was found on the Brief Pain Inventory. Pain reduction was still present at six months follow-up. All domains, in particular bodily pain, of the SF-36 showed improvement in the short term. After six months of follow-up, bodily pain was still strongly and significantly reduced, whereas social functioning and role physical

	NMES) per day for a total of six weeks.	demonstrated a nonsignificant improvement of more than 10% compared with baseline.
Yu et al. 2004 USA 7 (RCT)	7 site, single-blinded, randomized clinical trial. 61 chronic stroke survivors with shoulder pain and subluxation volunteered to be randomized to receive intramuscular neuromuscular electric stimulation (NMES) to the supraspinatus, posterior deltoid, middle deltoid, and trapezius for 6 hours a day for 6 weeks or to the control condition of a cuff-type sling for 6 weeks. Main outcome measure Brief Pain Inventory question.	The main outcome measure was the Pain outcome measure Brief Pain Inventory question 12 (BPI 12), an 11-point numeric rating scale, assessed at the end of treatment, and at 3 and 6 months post treatment. Post stroke shoulder pain was significantly less in the NMES group compared to control at 3 and 6 months following treatment.
Chae et al. 2005 USA 7 (RCT)	12 month follow up from Yu et al. 2004. Treatment success was defined as a minimum 2-point reduction in Brief Pain Inventory question 12 at all post treatment assessments. Secondary measures included pain-related quality of life (Brief Pain Inventory question 23), subluxation, motor impairment, range of motion, spasticity, and activity limitation.	22 patients in the intervention group and 21 patients received 12-month assessments. The electrical stimulation group exhibited a significantly higher success rate than controls (63% vs. 21%). Repeated-measure analysis of variance revealed significant treatment effects on post treatment Brief Pain Inventory questions 12 and 23. There were no other significant between group differences.
Church et al. 2006 UK 9 (RCT)	176 stroke patients (≤ 10 days post-stroke) were randomly assigned to receive surface neuromuscular electrical stimulation (sNMES) or placebo with a sham stimulator for 4 weeks. Both groups received standard stroke unit care. One and 3-month assessments included Action Research Arm Test (ARAT), Frenchay Arm Test, Motricity Index (MI), Star Cancellation Test, pain scales, disability, global health status, and Oxford Handicap Scale.	There was no significant difference in the ARAT scores, the primary outcome, between groups. There were no other significant differences between the groups with the exception of: the gross and grasp subsections of the ARAT, the arm section of the MI and the Frenchay Arm Test, where the control group fared better at 3 months.
Chae et al. 2007 USA 7 (RCT)	Secondary analyses from Yu et al. 2004 & Chae et al. 2005. Forward stepwise regression was used to identify factors predictive of treatment success among participants assigned to the electrical stimulation group. Treatment success was defined as at least a 2-point reduction on the Brief Pain Inventory Question 12 at 12 months following treatment.	Time from stroke onset was most predictive of treatment success. Subjects were divided according to the median value of stroke onset: early (< 77 weeks) versus late (> 77 weeks). Electrical stimulation was effective in reducing poststroke shoulder pain for the early group (94% vs 7%, $p < .001$) but not for the late group (31% vs 33%). FIM score was the second strongest predictor. Factors which were not predictive included age, stroke type, gender, Fugl-Meyer score and side of hemiplegia.
Koyuncu et al. 2010 Turkey 4 (RCT)	50 rehabilitation inpatients with shoulder subluxation and shoulder pain were randomized to receive a 4-week treatment of conventional rehab or conventional rehab + 20 sessions of FES (1 hr/day x 5 days/wk, frequency 36 Hz) to the supraspinatus and posterior deltoid muscles. The shoulder pain of all patients	There were no significant between group differences in terms of pain, PROM or AROM. However, there was a significant difference between the two groups for the amount of change in shoulder subluxation in favor of the study group.

	during resting, passive range of motion (PROM) and active range of motion (AROM) was measured with the visual analog scale (VAS) while the shoulder subluxation levels were evaluated with the classification developed by Van Langenberghe and by using the millimetric measurements on anteroposterior shoulder X-ray before and after the physical treatment and rehabilitation program and compared.	
--	--	--

Discussion

Most of the RCTs reviewed reported a benefit associated with electrical stimulation, although there was variability in the outcomes assessed: range of motion, muscle tone, EMG activity, shoulder subluxation, shoulder pain and muscle function. The majority of trials evaluated surface FES while Yu et al. 2004 and Chae et al. 2005, 2007 evaluated intramuscular devices. One trial evaluated treatment with TENS. The results suggest that FES can reduce pain in the affected shoulder and also improve upper extremity function. Percutaneously placed devices may improve treatment compliance, since surface FES can be painful. However, the results from the largest and most methodologically rigorous trial (Church

et al. 2006) suggest that FES treatment might actually be associated with harm and may worsen arm function, especially among those with severe paresis. The authors proposed several mechanisms to potentially explain this finding including over-use and over stimulation of the affected arm and the possibility that stimulation interfered with the motor re-learning processes, influencing and impeding upper limb recovery even after treatment ceased. These authors did not evaluate the benefit of FES with respect to reducing shoulder subluxation or spasticity, while noting that there is evidence that FES treatment has been shown to improve these parameters. A summary of the RCTs reviewed is presented in Table 9.

Table 9. Summary of RCTs Evaluating Electrical Stimulation for the Treatment of Hemiplegic Shoulder

Study/PEDro	n	Interventions	Outcome
Church et al. 2006 9	176	Surface FES vs. sham FES	Action Research Arm Test (-) Pain (-)
Yu et al. 2004 Chae et al. 2007, 2007	61	Intramuscular FES vs. sling	Pain (-)
Yu et al. 2001	10	Intramuscular FES vs. surface FES	Pain (intramuscular FES +)
Linn et al. 1999	40	Surface FES vs. no FES	Subluxation (-) Pain (-)
Kobayashi et al. 1999 5	17	Surface FES vs. no FES	Subluxation (+) Pain (-)
Leandri et al.	60	High-intensity TENS +	Passive range of motion (+ high-intensity TENS)

1990 5		Physical therapy vs. low-intensity TENS vs. PT vs. sham TENS + PT	
Wang et al. 2000 5	32	Surface FES vs. no FES	Subluxation (+ acute - chronic) Passive range of motion (-) Fugl-Meyer (+ acute - chronic)
Koyuncu et al. 2010 4	50	Surface FES vs. no FES	Subluxation (+) Pain (-)
Baker & Parker 1986 4	63	Surface FES vs. sling or wheelchair arm support	Subluxation (+)
Faghri et al. 1994 4	26	Surface FES vs. therapy	Subluxation (+) Pain (-)

Conclusions Regarding Electrical Stimulation in the Hemiplegic Shoulder

There is strong (Level 1a) evidence that that functional electrical stimulation does not reduce hemiplegic shoulder pain following stroke.

There is strong (Level 1a) evidence that FES does reduce shoulder subluxation.

Functional electrical stimulation may improve shoulder subluxation, but does not reduce pain in the hemiparetic shoulder.

1.6 Surgery as Treatment for Muscle Imbalance

Given that spastic muscle imbalance has been identified as a cause of hemiplegic shoulder pain, treatment designed to reverse that imbalance could potentially relieve hemiplegic shoulder pain.

Table 10. Surgery for Muscle Imbalance in the Hemiplegic Shoulder

Author, Year Country PEDro Score	Methods	Outcomes
Braun et al. 1971 USA No Score	Surgical procedure on 13 patients to release the insertion of the major muscle causing internal rotation and adduction of the shoulder. Gradual increase in range of motion was obtained by completing an intensive post-operative exercise therapy program involving passive range of motion, positioning of the shoulder, abduction while supine, through the use of reciprocal pulley exercises.	10 of the 13 patients operated on regained 90 degrees of passive abduction and 20 degrees of external rotation within 2 months following surgery. However, 6 months later, all of the patients were complaining of pain and discomfort.

Conclusions Regarding Surgery as Treatment for Hemiplegic Shoulder Pain

There is limited (Level 2) evidence that surgically resecting the subscapularis and pectoralis muscle tendons improves pain and range of motion in

stroke patients with a painful hemiplegic shoulder. Further research is needed to confirm these findings.

1.7 Botulinum Toxin Injections as Treatment for HSP

As discussed previously, subscapularis spasticity is characterized by shoulder range of motion being most limited with pain being reproduced on external rotation. This appears to correlate well with hemiplegic shoulder

pain that is now thought to be a consequence of spastic muscle imbalance about the shoulder in many cases. Pectoralis muscle spasticity, characterized by limitation of range and pain on shoulder abduction, is seen to a lesser extent, causing a similar muscle imbalance. Intra-articular injections of steroids, botulinum toxin and other agents have been used in an effort to treat spastic muscles, redress the imbalance and to relieve hemiplegic shoulder pain.

Table 11. Botulinum Toxin for Hemiplegic Shoulder Pain

Author, Year Country PEDro Score	Methods	Outcomes
Hecht 1992 No Score	A retrospective study of 13 patients with spastic hemiplegia, limited ROM and painful shoulder and with duration of hemiplegia for 2 to 13 months. Patients received percutaneous phenol nerve blocks to subscapularis muscle innervation.	Immediate and significant improvement in ROM observed in abduction, flexion and external rotation. Relief of pain was noted with previously painful movements.
Hecht 1995 No Score	Prospective study of 20 patients receiving botulinum toxin muscle blocks to the subscapular and pectoralis major musculature.	85% benefited from subscapularis block, and 55% benefited from pectoralis major block and 45% showed improved active ROM.
Bhakta et al. 1996 UK No Score	17 patients received a single course of intramuscular botulinum toxin to biceps brachii, flexor digitorum profundus, flexor digitorum superficialis and flexor carpi ulnaris.	Shoulder pain improved in 6 of 9 patients with shoulder pain.
Yelnik et al. 2007 France 7 (RCT)	20 hemiplegic patients with upper limb spasticity due to stroke were randomly assigned to receive either one injection of Botulinum toxin A (BT-A; 500 units) (n=10) or placebo (n=10) in the subcapularis muscle. Non-standardized physical therapy was given to both groups on weekdays. Pain was measured using a 10-point visual analogue scale.	Pain decreased from 7.5 to 1.5 by week 4 in the treatment group and from 5.5 to 4 in the control group (p=0.025). There was also significant improvement in lateral rotation (mean 12.5% vs. -2.5%, p=0.018), but not for change in abduction (shoulder range of motion observed in the treatment group (70% vs. 72.5%).
Kong et al. 2007 Singapore 8 RCT	17 patients recruited from an outpatient clinic with spastic shoulder pain resulting from a stroke that occurred more than 3 months later were randomized to receive a single injection of 500 U of Dysport (n=8) or saline placebo (n=9), injected into the pectoralis major and biceps brachii. Pain was the primary outcome	At week 4 there was no significant difference in the resolution of shoulder pain between the groups. (Dysport: median VAS decreased from 6 to 4, placebo: decreased from 6 to 3). Subjects who received Dysport showed significantly greater improvements in median shoulder adductor and elbow flexor Ashworth Scale scores than placebo

	assessed on a 10 point VAS at 4 weeks following treatment. Muscle tone and passive range of shoulder abduction were also assessed at weeks 4,8 and 12.	at week 4 but not at week 8 and 12.
Marco et al. 2007 Spain 8 RCT	31 patients with moderate to severe spastic shoulder pain, 3 or more months post stroke, admitted for inpatient rehabilitation were randomized to receive treatment with either TENS (short pulses of high frequency and low intensity for 6 weeks) + 500 U of Dysport injected into 4 sites of the pectoralis major muscle of the paretic side under EMG guidance (n=16), or TENS + placebo (n=15). Pain was assessed on a 100 point VAS at 1 week, 1,3 and 6 months. Other outcomes assessed included spasticity (MAS) and shoulder range of motion (flexion, abduction, and external rotation)	Pain was reduced significantly more among patients in the treatment group by the end of 6 months (76.4 to 30.1 vs. 70.1 to 48.3, time x treatment interaction p = 0.035). The degree of external rotation was also increased significantly more among patients in the treatment group (7.9 to 38.9 vs. 6.7 to 19.3, group x time interaction, p=0.041). There were no other statistically significant differences between the groups.
De Boer et al. 2008 The Netherlands 6 (RCT)	22 stroke patients with spastic hemiplegia, substantial shoulder pain and reduced external rotation of the humerus were randomized to receive a single injection of either botulinum toxin A BT-A (2x50 units) or placebo applied to the subscapularis muscle at two locations. Pain was scored on a 100 mm vertical Visual Analogue Scale (VAS); external rotation was recorded by means of electronic goniometry. Assessments were carried out at 0 (baseline), 6 and 12 weeks	While pain decreased over time in both groups, there was no significant treatment effect of BT-A. Similarly, external rotation improved significantly over time with no between group difference.
Pedreira et al. 2008 Brazil No Score	In an open label study, 15 patients with spastic hemiparesis secondary to stroke received a single injection of BT-A (average dose 280 IU). Assessments were performed at 1, 2 and 4 months after treatments and included pain (0-10 visual analog scale) and goniometry (abduction, extension, flexion and rotation). All subjects received physical therapy.	The mean pain score was reduced non-significantly over the study period (from 8 to 6); however, there was a significant improvement in flexion and rotation.
Ashford & Turner-Stokes 2009 UK No Score	16 rehabilitation outpatients received an individualized dose of BoNT-A (Dysport) (100-500U) injection and concurrent therapy for spasticity of the shoulder girdle or proximal upper limb following stroke/other acquired brain injury. Functional goals for intervention were determined through agreement with the patient or their carers using Goal Attainment Scaling (GAS). Evaluation of	The mean time since injury was 15.7 months. Sixteen weeks post-injection, significant improvements were identified in spasticity (p<0.001) and passive function (p=0.002), but not pain (p=0.052). GAS scores had improved in all but one subject, with goals either achieved or over-achieved.

	spasticity (Modified Ashworth Scale), pain (numbered graphic rating scale) and three standard passive function tasks (washing, dressing and positioning) were also undertaken.	
--	--	--

Discussion

Four RCTs, all of good quality assessed the efficacy of botulinum toxin in the treatment of hemiplegic shoulder. The subscapularis muscle was the most common injection site. The inclusion criteria were generally strict which resulted in small sample sizes, and suggests that the trials may not have been adequately powered.

The heterogeneity of treatments and doses hinder the process of formulating conclusions. The two trials that demonstrated a benefit of treatment in terms of pain reduction (Marco et al. 2007, Yelnik et al. 2007) used either a higher dose of Botox or added treatment with TENS. The results from these trials are summarized below.

Table 12. Summary of RCTs Evaluating Botulinum Toxin

Study/PEDro	n	Interventions	Outcome
Kong et al. 2007 8	17	500 U Dysport vs. placebo	Pain (-) Modified Ashworth Score (-) Range of motion (-)
Marco et al. 2007 8	31	TENS + 500 U Dysport vs. TENS + placebo	Pain (+) Modified Ashworth Score (-) Range of Motion (+/-)
Yelnik et al. 2007 7	20	500 U Botox vs. placebo	Pain (+) Range of Motion (+/-)
De Boer et al. 2008 6	22	100 U Botox vs. placebo	Pain (-) Range of motion (-)

Conclusions Regarding Botulinum Toxin for Shoulder Pain

There is conflicting (Level 4) evidence that botulinum toxin injected into the subscapularis muscle reduces spastic shoulder pain and improves passive range of motion of the hemiplegic shoulder.

It is uncertain whether botulinum toxin reduces hemiplegic shoulder pain

1.8 Steroid Injections as Treatment for HSP

The use of a triamcinolone acetonide injection into the glenohumeral joint has also been examined as a means to relieve shoulder pain in patients with hemiplegia. Five trials were identified which examined the use of steroids following stroke.

Table 13. Steroid Injections for Hemiplegic Shoulder Pain

Author, Year Country PEDro Score	Methods	Outcomes
Dekker et al. 1997 Netherlands No Score	9 patients with a presence of shoulder pain in the paretic arm with disturbances of sleep and with the presence of ROM restriction of external rotation partook in a multiple-baseline (AB) study of triamcinolone acetonide. The treatment condition (phase B) was 4 weeks long, during which three intra-articular injections of triamcinolone acetonide were administered at day 1, 8 and 22.	Intra-articular injections of triamcinolone acetonide demonstrated a significant reduction in pain with highly significant effect in 5 of the 9 patients. Range of motion improved in 4 out of 7 patients but improvement did not reach statistical significance at the group level.
Snels et al. 2000 Netherlands 8 (RCT)	35 patients demonstrating hemiplegia after stroke and pain in hemiplegic shoulder greater than 4 on the visual analogue scale (VAS) with limitation of passive external rotation of the hemiplegic shoulder were randomized to receive either three injections with triamcinolone acetonide (40 mg Kenacrot A-40 in 1ml) or three placebo injections (1 ml saline solution).	No significant improvement was observed for any of the primary outcome measures with triamcinolone acetonide treatment.
Lim et al. 2008 South Korea 9 (RCT)	29 stroke patients with shoulder pain were randomized to receive intramuscular injections of i) Botulinum toxin (BT-A) (100 U total) during one session to the infraspinatus, pectoralis and subscapularis muscles in conjunction with an intraarticular injection of normal saline to painful shoulder joint (n=16), or an intraarticular injection of triamcinolone acetonide (TA) (40 mg) and an intramuscular injection of normal saline to the same muscles. Outcome measures were pain (measured using a numeric rating scale), physician's global rating scale, shoulder range of motion (ROM) in 4 directions, arm function measured using Fugl-Meyer score, and spasticity measured using the modified Ashworth scale. Measurements were made at baseline and 2, 6, and 12 weeks after injection.	At 12 weeks after treatment mean decrease in pain was 4.2 in the BT-A group and 2.5 in the TA-treated group (p=0.051), and improvements in overall ROM were 82.9 degrees versus 51.8 degrees in these groups (p=0.059). There were no significant differences between the 2 groups in terms of improvement in physician global rating, Fugl-Meyer score or modified Ashworth scales.
Chae & Jedlicka 2009 USA No Score	10 stroke patients from an outpatient clinic with pain in the hemiparetic shoulder received a single subacromial injection of 60 mg triamcinolone acetonide + 2.5 mL of 1% lidocaine. The primary outcome measure was the Brief Pain Inventory (BPI) question 12	The mean BPI I2 score before treatment was 7.8. Mean scores declined significantly over the study period. The mean BPI 12 score was 3.8 at week 12. The greatest decrease was seen at the end of week 2. Repeated measure analysis of variance revealed significant within group x time

	(BPI 12), which assesses "worst pain" in the previous 7 days. Secondary measures included BPI question 15, which assesses present pain and BPI question 23 (BPI 23), which assesses pain interference with 7 daily activities. Outcomes were assessed at baseline, weekly for the first 4 weeks and then at 8 and 12 weeks post injection.	effect.
Laske et al. 2009 Turkey 4 (RCT)	38 stroke patients with hemiplegic shoulder (etiology either frozen shoulder or impingement syndrome) were admitted to an inpatient rehabilitation unit. All patients received conventional therapy including 5 sessions of transcutaneous electrical stimulation over 3 weeks. Patients were randomized to receive no additional treatment, or a single injection of triamcinolone acetonide. Patients in the injection group received either intra-articular or subacromial injections of corticosteroid and local anesthetic according to their pathology. The evaluations were performed before treatment and at the first and fourth weeks of treatment. Primary outcome measures were passive shoulder range of motion and verbal analog scale for shoulder pain. Additional outcomes included BI, Brunnstrom upper-extremity score, and modified Ashworth scale.	Compared with baseline, patients who received a steroid injection had significantly greater improvement in pain (at rest, at night and during activity) and shoulder range of motion. There were no significant differences between groups on any of the secondary outcomes assessed.

Discussion

Three RCTs examined the potential benefit of steroid injection in the treatment of HSP. The results from two trials suggested no benefit. The third trial reported a benefit when steroid injection was added to a conventional rehabilitation program which also included treatment with

TENS. In the single trial that compared triamcinolone acetonide with botulinum toxin the results are more difficult interpret since subjects in each group improved (Lim et al. 2008). Despite a lack of statistical significance, the authors of this trial suggested that treatment with Botox was still superior and the effects longer lasting.

Table 14. Summary of RCTs Evaluating Triamcinolone Acetonide

Study/PEDro	n	Interventions	Outcome
Lim et al. 2008 9	29	triamcinolone acetonide (40 mg) vs. 100 Botox-A	Pain (-) Range of Motion (-)
Snels et al. 2000 8	35	triamcinolone acetonide (40 mg) vs. placebo	Pain (-) Action Research Arm Test (-)

			Fugl-Meyer (-)
Laske et al. 2009 4	38	triamcinolone acetonide vs. no injection	Pain (+) Range of Motion (+) Brunnstrom, BI (-)

There is conflicting (Level 4) evidence that intra-articular steroid injections improve pain associated with hemiplegic shoulder.

There is strong (Level 1a) evidence intra-articular steroid injections do not improve arm function compared with either botulinum toxin or placebo.

1.9 Aromatherapy/Acupressure Treatment for Shoulder Pain

Aromatherapy has been shown to help reduce pain and anxiety associated with chronic pain conditions (Buckle, 1999). The use of aromatherapy plus acupressure in the treatment of hemiplegic shoulder pain has been investigated in a single RCT.

Table 15. Aromatherapy Acupressure in the Treatment of Hemiplegic Shoulder Pain

Author, Year Country PEDro Score	Methods	Outcomes
Shin & Lee 2007 Korea 6 RCT	30 patients with stroke of onset less than 30 days with hemiplegic shoulder pain were randomized to either dry acupressure (n=15) or acupressure combined with 3 essential oils (rosemary, lavender and peppermint) (n=15). Treatment was provided twice daily (20 min sessions) for 2 weeks. A 7-point VAS was used to assess pain before and after treatment.	Before treatment median pain scores were similar between groups (6 vs. 6). At the end of treatment there was significantly greater pain reduction in the aromatherapy group (2 vs. 4, p=0.001).

The authors speculated that the improvement in shoulder pain might result from an enhancement of the parasympathetic response through the effects of smell and touch that encourage relaxation. Relaxation has been shown previously to alter the perception of pain.

There is moderate (Level 1b) evidence that aromatherapy combining with acupressure can reduce pain associated with painful hemiplegic shoulder.

Conclusions Regarding Aromatherapy Acupressure

1.10 Massage Therapy

Massage therapy has also been examined as a treatment for HSP.

Table 16. Studies Assessing Massage Therapy For HSP Following Stroke

Author, Year Country PEDro	Methods	Outcomes
Mok & Woo	102 stroke patients were randomly	Significant improvements in all 5 variables

2004 Hong Kong 5 (RCT)	allocated to a massage group or a control group. The treatment group receives 10-minutes of slow-stroke back massage (SSBM) for seven successive evenings. 5 variables were evaluated in the study: anxiety level, heart rate, systolic blood pressure (BP), diastolic BP and pain score.	at post-test and 3-days post-test were seen for the massage group compared to the control group ($p < 0.05$).
------------------------------	---	---

Mok and Woo (2004) conducted a RCT evaluating the healing effects of slow-stroke back massage for elderly stroke patients with shoulder pain and anxiety. All the participants reported beneficial effects from the massage intervention, which included relief of pain, relaxation and ability to sleep better. Also, massage therapy patients had significantly lower blood pressure, lower levels of anxiety, lower pain and heart rate scores when compared with the control group.

Conclusions Regarding Massage Therapy

There is moderate (Level 1b) evidence from one “fair” quality RCT that massage

therapy reduces pain and anxiety levels post-stroke.

1.11 Subscapular Nerve Block for the Treatment for Shoulder Pain

While suprascapular nerve block has been used to treat shoulder pain and improve range of motion in a variety of conditions including rotator cuff tendonitis, rheumatoid arthritis and frozen shoulder, it had not been evaluated specifically for used for hemiplegic shoulder pain previously. One small RCT has been published recently evaluating this treatment for post-stroke shoulder pain, compared with usual care, which was, in this case, ultrasound.

Table 17. Studies Assessing Nerve Block For HSP

Author, Year Country PEDro	Methods	Outcomes
Boonsong et al. 2009 Thailand 4 (RCT)	10 stroke patients with hemiplegic shoulder pain who met the inclusion criteria were randomized to receive suprascapular nerve block (SSNB) with 2 separate injections of 10 mL of 1% lidocaine or ultrasound therapy 5 days a week for 4 weeks. During the study period all of the patients were given the same program of range of motion exercise. Outcomes were assessed at baseline and 2 and 4 weeks and included pain (0-100 VAS) and range of motion (ROM).	At baseline, pain scores were similar between groups (71 and 72). At week 4, the pain scores were significantly reduced in the nerve block group (20 vs. 50, $p = 0.004$). There were no significant differences between groups on ROM measures in either flexion and abduction at any time point.

Conclusions Regarding Subscapular Nerve Block

There is moderate (Level 1b) evidence that subscapular nerve block reduces hemiplegic shoulder pain compared with ultrasound therapy.

1.12 Summary of the Management of Hemiplegic Shoulder

Despite the high prevalence of patients suffering from painful hemiplegic shoulders, the evidence for effective treatment is underwhelming and no particular intervention appears superior. A recent systematic review and meta-analysis, limited to the inclusion of 8 RCTs (Koog et al. 2010) reported that aromatherapy/acupressure, slow back massage and intramuscular neuromuscular electrical stimulation were more effective than the placebo condition. However, only electrical stimulation was assessed and found to be effect long-term (3 months). The effect size associated with treatment was -1.173 (95% CI -1.943 to -0.403). The authors also reported there was no association between spasticity and HSP.

There is conflicting evidence that electrical stimulation helps to reduce pain and subluxation, and conflicting evidence that botulinum toxin can help to reduce pain or spasticity. There is moderate evidence supporting an active therapy-oriented approach,

although overaggressive therapies using pullies substantially increases pain when compared to gentler range of motion therapy approaches. There is insufficient evidence that positioning of the shoulder or shoulder strapping prevent subluxation, decrease pain or increase functionality.

There have been no RCTs conducted on the use of slings, motor blocks for spastic muscle imbalance or providing NSAID medications prior to therapy, although there is limited evidence of a benefit for all three of these treatment approaches.

There is consensus opinion that prevention and avoidance of overaggressive therapy is important. Those individuals caring for the stroke patient, particularly early on, should be aware of the potential for shoulder injury. The shoulder should be carefully positioned and supported against gravity while sitting or standing. Range of motion exercises should not carry the shoulder beyond 90 degrees of flexion and abduction unless there is upward rotation of the scapula and external rotation of the humeral head (Gresham et al. 1995).

Table 18. Summary of RCTs for Management of Hemiplegic Shoulder

Author, Year	PEDro Score	n	Outcomes
Positioning of the Shoulder			
Dean et al. 2000	5	23	-
Ada et al. 2005	6	36	+/-
Gustafson & McKenna 2005	6	32	-
DeJong et al. 2006	6	19	-
Slings and Other Aids			
No RCTS	-	-	-
Strapping			
Hanger et al. 2000	7	98	-
Griffin & Bernhardt 2006	7	32	+
Active Therapies			

Inaba et al. 1972	7	33	-
Patridge et al. 1990	5	65	+
Kumar et al. 1990	5	28	-
Lynch et al. 2005	6	35	-
Electrical Stimulation			
Koyuncu et al. 2010 (FES vs. no FES)	4	50	+/-
Baker et al. 1986 (FES vs. sling)	4	63	+
Faghri et al. 1994 (FES vs. therapy)	4	26	+
Kobayshi et al. 1999 (FES vs. no FES)	5	17	+
Leandri et al. 1990 (TENS vs. sham TENS)	5	60	+
Linn et al. 1999 (FES vs. no FES)	6	40	+/-
Wang et al. 2000 (FES vs. no FES)	5	32	+
Yu et al. 2001 (Intramuscular FES vs. surface FES)	6	10	+
Yu et al. 2004 & Chae et al. 2005 & Chae et al. 2007 (Intramuscular FES vs. sling)	7	61	+
Church et al. 2006 (FES vs. sham FES)	9	106	-
Surgery for Muscle Imbalance			
No RCTs	-	0	-
Injections of Steroid or Botulinum toxin			
DeBoer et al. 2008 (botulinum toxin vs. placebo)	6	22	-
Yelnik et al. 2007 (botulinum toxin vs. placebo)	7	20	+
Kong et al. 2007 (botulinum toxin vs. placebo)	8	17	-
Marco et al. 2007 (TENS + botulinum toxin vs. TENS + placebo)	8	31	+/-
Snels et al. 2000 (steroid vs. placebo)	8	35	-
Lim et al. 2008 (botulinum toxin vs. steroid)	8	29	-
Laske et al. 2009 (steroid vs. no injection)	4	38	+/-
Boonsong et al. 2009 (steroid vs. ultrasound)	4	10	+/-
Massage/Other			
Mok & Woo (slow back massage)	5	102	+
Shin & Lee. 2007	6	30	+

2.0 Treatment of Chronic Regional Pain Syndrome-Type 1 (CRPS-1)

CRPS is the more recent nomenclature for referring to shoulder hand syndrome or reflex sympathetic dystrophy. Other terms including causalgia, Sudek's atrophy and neuroalgodystrophy have also been used. CRPS following stroke refers to type 1 and is characterized by numerous peripheral and central nervous system changes. Peripheral changes include vasomotor tone with associated hand pain and swelling,

exquisite tenderness or hyperaesthesia, protective immobility, trophic skin changes and vasomotor instability of the involved upper extremity. Central changes include a disruption of sensory cortical processing, disinhibition of the motor cortex and disrupted body schema (Moseley et al. 2004).

The condition is not unique to patients recovering from stroke, but is also associated with phantom limb pain, and is prevalent among patients with head injury, spinal cord injury and even mild injury to the extremities.

Prevention of shoulder problems and aggressive early treatment are recommended to prevent the development of a non-functional painful upper extremity. The various treatment options are outlined in Table 17. Therapy consists of vigorous physiotherapy with a focus on range of motion exercises. Although physiotherapy is regarded as the cornerstone of integrated treatment, no controlled trials have been conducted to evaluate the effect of treatment. A one to two week course of high dose corticosteroids and/or sympathetic blocks either in the form of stellate ganglion blocks or guanethedine local venous blocks may be tried in persistent disabling cases. Constraint-induced movement therapy and sensory discrimination training have also been proposed as possible

treatments for SHS (Acerra et al. 2007). A surgical sympathectomy may be considered if stellate ganglion sympathetic blocks are consistently effective but symptoms recur. However, there is no evidence that surgical sympathectomy alter outcomes. There is no definitive therapeutic intervention for reflex sympathetic dystrophy, as reflected by the large number of suggested treatments. In fact, it is widely accepted that there is little evidence that many of the commonly-used treatments associated by SHS are effective (Pertoldi & Benedetto 2005, Quisel et al. 2005). Shoulder hand syndrome, which presents for greater than 6 months without appropriate treatment, has a poor prognosis (Lieberman 1986).

Table 17. Potential Treatments for CRPS-1

<p>Prevention</p> <ul style="list-style-type: none"> •Extremely early ROM exercises •Avoid shoulder subluxation <p>Exercise</p> <ul style="list-style-type: none"> •Prevention and treatment of upper extremity contractures •Active exercise if possible •Frequent passive ROM <p>Modalities</p> <ul style="list-style-type: none"> •Interferential deep heat •Heat/cold modalities especially contrast baths •Hand desensitization program •Transcutaneous electrical nerve stimulation 	<p>Splints</p> <ul style="list-style-type: none"> •Resting splint of hand and wrist (controversial) <p>Medication</p> <ul style="list-style-type: none"> •Analgesics •NSAIDs •High dose oral corticosteroids (10 day course and then taper) <p>Injections</p> <ul style="list-style-type: none"> •Stellate ganglion sympathetic block •Guanethedine bier block <p>Surgical</p> <ul style="list-style-type: none"> •Sympathectomy
---	---

2.1 Pharmacological Treatment of CRPS-1

Four studies evaluated drug therapies for the treatment of SHS associated with stroke. The results are presented in Table 18.

Table 18. Corticosteroid Treatment for CRPS-1

Author, Year Country PEDro Score	Methods	Outcome
Davis et al. 1977 New York No Score	A retrospective study of 68 patients suffering from hemiparesis and SHS resulting from stroke. All patients received 16 mg of an oral steroid (triamcinolone diacetate) daily for 14 to 21 days. Patients self-described their pain.	All patients became pain-free, when subjected to passive stretching of the involved joints, within 3 weeks. Six patients experienced a relapse of their pain, which resolved during a second course of treatment.
Braus et al. 1994 Germany 5 (RCT)	36 hemiplegic patients secondary to a stroke of the middle cerebral artery and exhibited definite shoulder-hand syndrome were studied. Patients were randomized to orally receive either 8 mg methylprednisolone or a placebo over 4 weeks. All patients received daily physical therapy. For patients in the placebo group, if no improvement was noted in shoulder-hand syndrome then they were given 4 weeks of corticosteroid treatment as per the experimental group.	No significant improvement was noted in shoulder-hand syndrome in the placebo group after 4 weeks at which time all patients switched over the corticosteroid protocol. Patients receiving the corticosteroid treatment demonstrated significant improvement in shoulder-hand syndrome that was maintained at 6 months. 31 of the 36 patients became almost symptom free within 10 days of treatment with low dose oral corticosteroids.
Hamamci et al. 1996 Turkey No Score	A controlled trial of 41 hemiplegic patients with grades 1-2 of SHS. All patients received conventional physical therapy as part of inpatient rehabilitation. 25 patients received 1 x 100 IU salmon calcitonin daily for 4 weeks and 16 patients received a saline injection as a placebo. Pain was measured on a 7-point visual analogue scale at the beginning and end of treatment	By the end of the 4 th week patients receiving calcitonin had significantly lower median pain scores compared to the controls (1 vs. 5). Patients receiving calcitonin treatments also reported less tenderness and improved range of motion. There was no difference in hand edema between groups.
Kalita et al. 2006 India 7 (RCT)	60 patients who developed CRPS-I following stroke were randomly assigned to receive 40 mg prednisolone or 20 mg piroxicam (NSAID) daily. CRPS-I was assessed at 1 month using a 0-14 point scale. The primary end point was a 2 or more point reduction in CRPS score.	Symptoms of CRPS developed a median of 28 days post stroke. In the prednisolone group, 83.3% patients showed significant improvement, compared to 16.7% in the piroxicam group. The mean change in CRPS score in prednisolone group was 6.47 (95%CI 4.37-7.36), whereas in piroxicam group it was only 0.47.

Discussion

The efficacy of corticosteroids for the treatment of CRPS-1 has not been well-studied. In only 2 RCTs identified, one in which placebo was used and one in which a NSAID was used as the alternative treatment. Steroids were demonstrated to be of benefit. braus et al. (1994) reported that oral

corticosteroids improved SHS for at least 4 weeks. Despite a limited number of trials, a review by Geurts et al. (2000) concluded that oral corticosteroids were the most effective treatment for SHS. While a single controlled trial found that calcitonin treatment effectively treated pain associated with CRPS-1, it is not widely used clinically.

Conclusions Regarding Oral Corticosteroids in CRPS-1

There is moderate (Level 1b) evidence that oral corticosteroids improves shoulder-hand syndrome for at least the first 4 weeks.

There is limited (Level 2) evidence that calcitonin improves pain associated with SHS following stroke.

Oral corticosteroids appear to improve CRPS-1 for at least the first 4 weeks.

2.2 Mirror Imagery as a Treatment for CRPS

Mirror therapy is a technique that uses visual feedback about motor performance to improve rehabilitation

outcomes. It can be used to improve motor performance, which is discussed in other chapters. Although it is more commonly associated with the treatment of phantom limb pain it may also be useful in the treatment of CRPS-1 post stroke. It is believed that mirror imagery helps to create a movement illusion of the affected arm with the brain. These mirror illusions are believed to compensate for a reduced or absent proprioceptive input and to re-establish the normal pain free relationship between sensory feedback and motor intention, resolving the pain state. The patient is seated in such a manner so that the unaffected limb may be viewed in the mirror (or mirror box), while the affected limb is concealed behind the mirror while performing a variety of movements with the upper limb.

Three RCTs examining the use of mirror therapy following stroke have been assessed.

Table 19. Studies Evaluating Mirror Therapy Post Stroke

Author, Year Country PEDro Score	Methods	Outcome
Moseley et al. 2004 Australia 6 (RCT)	13 chronic SHS patients were randomly allocated to a motor imagery program (MIP) or to ongoing management (usually pharmacological). The MIP consisted of two weeks each of a hand laterality recognition task, imagined hand movements and mirror therapy, each two weeks in duration. After 12 weeks, the control group was crossed-over to MIP.	There was a significant improvement in Neuropathic pain scale scores associated with MIP treatment which persisted at 6 weeks. The NNT to experience a > 50% reduction in pain was 3.
Cacchio et al. 2009a) Italy 7 (RCT)	48 patients admitted for inpatient rehabilitation with evidence of CRPS-1 of the affected upper limb participated receive a 4-week conventional rehabilitation program and were randomized to receive mirror therapy or to a control condition. All patients received 2-3 hours of therapies daily, 5 days/week. Patients in the intervention group were seated with the arms perpendicular to the	The mean scores of both the primary and secondary end points significantly improved in the mirror group (P < .001). No statistically significant improvement was observed in any of the control group values (P > .001). Moreover, statistically significant differences after treatment (P < .001) and at the 6-month follow-up were found between the 2 groups. At 6-months follow up, the mean pain scale score at rest (0-10)

	mirror board. Patients observed the reflection of their unaffected arm while performing movements with their affected arm. Patients in the control group performed the same movements, but the mirror was covered. The primary end points were a reduction in the visual analogue scale score of pain at rest, on movement, and brush-induced tactile allodynia. The secondary end points were improvement in motor function as assessed by the Wolf Motor Function Test and Motor Activity Log. Assessments were conducted before/after treatment and at 6 months.	was 4.7 vs. 8.1.
Cacchio et al. 2009b) Italy (RCT) Letter – insufficient info to enable scoring	24 stroke patients were randomized to one of three treatment groups: active mirror group as described above, a covered mirror group and a mental imagery group. In the 2 mirror groups, patients performed a variety of movements with the upper limb for 30 min per daily. Following 4 weeks of treatment, subjects in the 2 non-active mirror therapy groups were crossed over to the active mirror therapy group. Outcome measures, assessed at baseline and 8 weeks included pain on a VAS scale (0-100) and the Wolf-motor function test.	The mean VAS pain scores at baseline ranged from 62-64 at baseline across groups. After 4 weeks, patients in the active mirror therapy group had the lowest pain scores (5) vs. 80 (mental imagery group) vs. 72 (covered mirror group). At the end of 8 weeks, following crossover to active therapy the mean VAS pain scores were 10 or lower.

Among the 3 studies described above, one (Moseley et al. 2004) included mirror therapy as one component of the three- part treatment Motor Imagery Program (MIP). The mechanisms underlying motor imagery remain unclear, although it is known that both real and imagined movements activate similar cortical networks. Proposed mechanisms include reconciliation of motor output and sensory feedback, activation of mirror neurons and graded activation of cortical motor networks (Acerra et al. 2007).

In the first phase of the treatment hand laterality recognition, avoidance of activation of the primary motor cortex was achieved by only initiating activation in the pre-motor cortices. In the second stage, patients were asked to imagine their own hand placed in

the same position as a picture selected from 28 pictures chosen at random. In the final stage, pictures of the unaffected hand were placed into a cardboard mirror box. Patients were asked to adopt the posture in the picture (n=20) times with both hands, but to discontinue if they experienced pain.

Moseley et al. (2004) reported that treatment with MIP was more effective than ongoing medical management of CRPS. Patients experienced significant reductions in pain and swelling associated with treatment, which persisted for at least 6 weeks. The authors also noted that 6 weeks after completing the MIP program, approximately 50% of patients no longer fulfilled the diagnostic criteria for CRPS1.

Mirror therapy, when provided as a single intervention was found to be more effective in reducing pain than either sham mirror therapy or mental practice. The effects were also reported to be long lasting. (Cacchio et al. 2009a).

Conclusions Regarding Mirror Therapy Post Stroke

There is strong (Level 1a) evidence that mirror therapy can reduce pain associated with shoulder-hand syndrome.

A mirror therapy program appears to improve shoulder-hand syndrome.

2.3 Controlled Passive Range of Motion Exercises for the Prevention of CRPS-1

Although physiotherapy is regarded as the cornerstone of integrated treatment, no controlled trials have been conducted to evaluate its effect in preventing the development of CRPS-1. A single trial using historical controls evaluated the benefit of an exercise program to reduce the incidence of CRPS following stroke (Table 20).

Table 20. Physical Therapy to Prevent CRPS-1

Author, Year Country PEDro Score	Methods	Outcome
Kondo et al. 2001 Japan No Score	152 stroke patients admitted to a rehabilitation unit and followed for approx. 200 days were monitored for the development of RSD, assessed clinically by a physician. Half of the patients were treated with a protocol to prevent RSD, consisting of passive ROM exercises, performed by therapists and restrictions on passive movement by patients. The remaining patients received standard inpatient rehabilitation.	The incidences of RSD were 15/81 (18.5%) for patients receiving the protocol and 23/71 (32.4%) among patients who did not.

The set protocol developed by the authors was in response to the observation that patients were inappropriately performing excessive passive range of motion exercises, which may have contributed to the development of CRPS-1. They hypothesized that by limiting inappropriate exercise and replacing it with a set protocol performed by therapists that they could reduce the incidence of CRPS-1.

Conclusions Regarding Physical Therapy to Prevent CRPS-1

There is limited (Level 2) evidence that passive range of motion exercises can prevent the development of CRPS-1.

2.4 Calcitonin for the Prevention of CRPS

Although calcitonin has been used successfully to treat osteoporosis, as well as a variety of pain conditions following surgery and trauma, its use in the treatment of CRPS-1 following stroke has not been examined

previously. Its mechanism of action is not well-understood and no site of action has been identified. A single historically controlled trial was

identified examining the benefit of intramuscular injections of calcitonin, in addition to regular rehabilitation.

Table 21. Calcitonin to Prevent CRPS

Author, Year Country PEDro Score	Methods	Outcome
Matayoshi et al. 2009 Japan No Score	24 hemiplegic patients admitted for inpatient rehabilitation with severe stroke and with any upper limb or finger graded as Brunnstrom stage III or below received conventional therapies plus a once-weekly intramuscular injection of 20 U of calcitonin. This group of patients was compared with a historical cohort of 35 that received rehabilitation therapy only. Patients were observed during the in-hospital rehabilitation period. The main outcome measure was onset of CRPS.	The incidence of CRPS in all patients with post-stroke hemiplegia during the control period was 8.2%. Among patients with severe stroke who received calcitonin, the incidence of CRPS was significantly lower compared with the control group (12.5% vs. 57.1%, $p < 0.001$). CRPS was completely prevented when calcitonin was started 4 weeks or earlier after stroke, but prophylactic effects were weak when calcitonin was started >6 weeks after stroke.

Conclusions Regarding Calcitonin to Prevent CRPS

There is limited (Level 2) evidence that intramuscular injections of calcitonin can prevent the development of CRPS.

various aetiologies (Nandi et al. 2002, Canavero and Bonicalzi 1999, Katayama 1998, Yamamoto et al. 1997, Katayama et al. 2001). There are few trials evaluating the efficacy of any of these treatments, which tends to be managed on a symptomatic basis.

3.0 Treatment of Central Pain Post Stroke

“Pain after stroke is a symptom often forgotten, unnoticed although it is reported to be a great problem in care.” (Widar and Ahlström 2002) Most neuropathic pain responds poorly to NSAIDS and opioid analgesics. As a result, the mainstay of treatment are predominantly tricyclic antidepressants (TCA's), anticonvulsants and systemic local anesthetics, antiarrhythmics, opioids, anti-epileptic agents and N-methyl-D-aspartate (NMDA) antagonists. Recently, post-stroke pain has been treated with motor cortex stimulation in various trials for mitigation of neuropathic pain of

Frese et al. (2006) conducted a systematic review of studies investigating pharmacologic treatment of central post-stroke pain. The review included seven small RCTs, six uncontrolled trials and one case series. The study reported that oral drugs effective in treating CPSP were amitriptyline and lamotrigine. Also, IV drugs effective for short-term control of CPSP included lidocaine, propofol and ketamine, however due to possible side effects and their application these drugs are inappropriate for long-term treatment. Gabapentin was also reported useful in controlling CPSP for several patients.

A recent Cochrane review (Wiffen & Ress, 2007) assessing the benefits of acute and chronic pain concluded that lamotrigine was not an effective treatment for post-stroke pain, based on the results from only a single RCT,

while Kumar et al. (2009) concluded that amitriptyline and lamotrigine should be considered as first-line drugs for CPSP following a recent review of the literature.

Table 22. The Treatment of Central Post Stroke Pain

Author, Year Country PEDro Score	Methods	Outcomes
Leijon & Boivie 1989(b) Sweden 6 (RCT)	A double- blind, 3 phase crossover placebo controlled trial of 15 patients. Treatment was given in randomized order, for 4 weeks, separated by 1 week wash-out periods in which patients were administered amitriptyline, carbamazepine and placebo.	Amitriptyline produced a significantly greater reduction of pain when compared to placebo at week 4.
Leijon & Boivie 1989(c) Sweden No Score	15 stroke patients received both high frequency and low frequency transcutaneous electrical nerve stimulation (TENS) 3x/day for 16 days. A 10-step verbal pain rating scale was used for the assessments (baseline, 60 and 120 minutes following stimulation). Final follow-up at 23-30 months.	4 patients obtained at least a 20% reduction in baseline pain (mean=42%). 3 patients continued to use TENS and reported an improvement in their pain symptoms for 23, 24 and 30 months.
Awerbuch et al. 1990 USA No Score	9 patients (8/9 with stroke) were administered 150 mg/day of mexiletine for 3 days followed by 300 mg/day for 3 days and thereafter at a dose of 10mg/Kg/day for one month.	Mexiletine produced a significant improvement in pain in 8 of the 9 patients.
Bainton et al. 1992 UK 5 (RCT)	20 stroke patients received both naloxone (up to 8 mg) and normal saline in a randomized crossover trial. Visual analogue scale and verbal pain scores were obtained immediately before and after injection. There was a 2 to 3 week washout period.	There were no immediate or long-term differences in pain relief between the 2 groups.
Yamamoto et al. 1997 Japan No Score	39 central post-stroke patients were tested with the 3 pharmacological tests including the morphine, thiamylal and ketamine tests. After the tests were completed patients were treated with motor cortex stimulation. Follow-up took place at 12-months since the start of stimulation.	At follow-up, chronic motor cortex stimulation proved only patients sensitive to thiamylal and ketamine, and resistant to morphine showed long-lasting reduction in pain.
Attal et al. 1998 France No Score	18 patients with peripheral nerve injuries or central lesions (2 CPSP patients) received gabapentin in gradually increasing doses of up to 2400 mg/day for a period of 6 weeks. Doses started at 300	Patients experienced a significantly relief of ongoing spontaneous pain and reduced paroxysmal pain.

	mg 2 times daily for the first 3 days, then the dose increased every 3 days.	
Katayama et al. 1998 Japan No Score	31 patients with post stroke pain were treated with motor cortex stimulation delivered through surgically implanted devices which delivered a pulse of 0.2 msec duration, frequency of 25-50 Hz and intensity of 2-8 V. Stimulation was applied for 10-20 min on each occasion.	Satisfactory pain control was achieved in 74% of (23) patients during the first one-week period. After one year 48% of these patients 15 continued to achieve satisfactory pain control, while the effect gradually diminished over time in the remaining 8 patients and was no longer evaluated by the patients as being effective.
Attal et al. 2000 France 6 (RCT)	16 patients (6 with stroke) received both lidocaine or saline intravenous injections 3 weeks apart in a randomized crossover trial. Patients recorded pain using a visual analogue scale every 15 min up to 120 minutes and again at 6 hours.	Lidocaine was significantly better than saline in reducing the intensity of spontaneous ongoing pain for up to 45 min following injection. However, by 6 hours post injection only one patient in the lidocaine group and no patients in the saline group reported significant pain relief.
Vick & Lamer 2001 USA No Score	Case report of a 68-year-old female with CPSP and long standing depression treated with ketamine. Her pain had been refractory to therapy with many agents including opioids, lidocaine, NSAIDS, mexilitine and antidepressants.	Following 14 mg of i.v. ketamine, the patients reported marked pain relief and reduced allodynia and hyperalgesia. Oral doses of 50 mg t.i.d were continued. Side effects were effectively managed with diazepam.
Katayama et al. 2001 Japan No Score	45 patients with post-stroke pain received spinal cord stimulation (SCS), and if that failed they were considered for deep brain stimulation (DBS) of the ventralis caudalis (VS) and/or motor cortex stimulation (MCS). A visual analog scale was used to evaluate the stimulation therapy.	Stimulation at higher levels produced more frequent satisfactory pain control (7% by SCS, 25% by DBS and 48% by MCS). Stimulation by VC, post-central, pre-central and pre-frontal cortices caused some painful sensation, but as the stimulation site was raised to higher levels the sensation was less frequent.
Vestergaard et al. 2001 Denmark 8 (RCT)	30 consecutive patients with CPSP from two centers were entered into a double-blind, placebo-controlled cross-over study evaluating lamotrigine. There were two 8-week treatment periods separated by 2 weeks of wash-out. The primary endpoint was the median value of the mean daily pain score during the last week of treatment while treated with 200 mg/d lamotrigine. Secondary endpoints were median pain scores while on lamotrigine 25 mg/d, 50 mg/d, and 100 mg/d; a global pain score; assessment of evoked pain; areas of spontaneous pain; and allodynia/dysesthesia.	Lamotrigine 200 mg/d reduced the median pain score to 5, compared to 7 during placebo (p = 0.01). No significant effect was obtained at lower doses. Twelve patients (44%) responded to the treatment. Lamotrigine only had significant effects on some of the secondary outcome measures. Oral lamotrigine 200 mg daily is a well tolerated and moderately effective treatment for central poststroke pain.
Attal et al. 2002 France 8 (RCT)	The efficacy of morphine infusion (9-30 mg) was assessed in a double-blind, placebo-controlled, crossover study of 15 patients with post stroke- (6 patients) or spinal cord injury- (9 patients) related	Morphine significantly reduced the intensity of brush-induced allodynia but had no effect on other evoked pains (i.e., static mechanical and thermal allodynia/hyperalgesia). The effects of

	pain. All of the patients subsequently received sustained oral morphine.	morphine on ongoing pain were not significantly different from those of the placebo, but 7 patients (46%) responded to morphine. There was a correlation between the effects of morphine on spontaneous pain and the decrease of the responses to suprathreshold thermal stimuli on the nonpainful contralateral side. Only 3 patients (20%) were still taking morphine after 1 year.
Shimodozono et al. 2002 Japan No Score	28 patients with central post-stroke pain received selective serotonin reuptake inhibitor (SSRI) fluvoxamine 50 mg/day divided into 2 weekly doses. Doses were either increased or maintained (maximum of 125 mg/day) depending on the symptoms of the patient with the treatment lasting 2 to 4 weeks. Evaluations took place before and after treatment. They included the visual analog scale (VAS) and Zung's Self-rating Depression Scale (SDS).	Following treatment patients' mean VAS and mean SDS significantly decreased ($p < 0.01$). After, patients were split up into 2 groups, the patients in whom the duration after stroke was less than 1 year post-stroke showed a significant reduction in VAS ($p < 0.001$), whereas patients who had longer than 1-year duration since stroke onset did not.
Serpell et al. 2002 UK 8 (RCT)	307 patients with a wide range of neuropathic pain syndromes (9 with post stroke pain) with at least two of the following symptoms: allodynia, burning pain, shooting pain, or hyperalgesia were randomised to receive either gabapentin (n=153) or placebo (n=152) for 8-weeks following a run-in period. Gabapentin was given in three divided doses, initially titrated to 900 mg/day over 3 days, followed by two further increases, to a maximum of 2400 mg/day if required by the end of week 5. The primary outcome measure was change in average daily pain diary score (baseline versus final week) using a 0-10 Likert scale.	Over the 8 week study, pain scores decreased 1.5 (21%) in gabapentin treated patients and by 1.0 (14%) in placebo treated patients ($P = 0.048$, rank-based analysis of covariance). Significant differences were shown in favour of gabapentin for the Clinician and Patient Global Impression of Change, and some domains of the Short Form-McGill Pain Questionnaire. Improvements were also shown in patient-reported outcomes in quality of life, as seen by significant differences in favour of gabapentin in several domains of the Short-Form-36 Health Survey.
Chen et al. 2002 USA No Score	Single case report of a 45 year old male with central post stroke pain, who had failed on a variety of treatments and who was given 300 mg oral gabapentin 3 x/day.	The reported pain intensity was significantly reduced on a 10-point pain scale to 4. Therapy and pain relief continued for a one-year period.
Lampl et al. 2002 Austria 7 (RCT)	39 stroke patients were randomly assigned to receive either amitriptyline (n=20) or placebo (n=19) over 1 year for the management of central pain.	There were no differences in the occurrence, intensity, type, site or distribution of pain between the 2 groups.
Rowbotham et al. 2003 USA 7 (RCT)	81 patients suffering from neuropathic pain were randomized to 1 of 2 groups: 1) High-strength (0.75-mg) (5 CPSP patients) or 2) low-strength (0.15-mg) (5 CPSP patients) capsules of μ -opioid	High-strength levorphanol capsules reduced pain by 36 percent, as compared with a 21 percent reduction in pain in the low-strength group ($P = 0.02$).

	agonist levorphanol for a period of 8 weeks.	
--	--	--

Discussion

Central pain is generally intractable to most therapeutic interventions. Narcotic and non-narcotic analgesics consistently failed to provide adequate pain relief (Nuzzo and Warfield 1985). Tricyclic antidepressants have been shown to have a beneficial effect on central pain states (Koppel 1986, Tourian 1987). In one controlled study (PEDro = 6), amitriptyline was shown to have some pain ameliorating effect on CPSP patients (Leijon and Boivie 1989b) (see table 17.13). The authors suggested that the reduction in pain was not attributable to an antidepressive effect. Phenothiazines (chlorpromazine) (Margolis 1956), anticonvulsants [phenytoin (Mlandinich 1974, Cantor 1972) and carbamazepine (Leijon 1989b)] are reportedly only minimally effective in reducing pain (Bowsher and Laheurta 1985). Apomorphine has been reported to be effective but associated with significant adverse effects and a tendency to lose its effectiveness over time (Miley et al. 1978).

Transcutaneous electrical nerve stimulation was reported to be effective in some CPSP patients (Leijon and Boivie 1989c). Sympathetic blockade in the form of stellate ganglion and lumbar sympathetic blocks or local venous guanethedine blocks may provide some temporary relief of pain (Loh et al. 1981). A variety of operative treatments have been tried for central pain states. These include neurosurgical brain lesioning (Davis and Stokes 1966, Mark et al. 1961, Nashold et al. 1969, White and Sweet 1969), brain stimulation (Meyerson 1979, Sweet 1982) and even stereotaxic chemical hypophysectomy (Levin et al. 1983). Overall, neurosurgical ablative procedures have been reported in uncontrolled studies to have a 25% effectiveness rate in permanently relieving central pain states but are associated with a significant risk of brain injury (Pagni 1977). Gonzales (1994) reported that resistance to treatment of CPSP can evoke severe depression, which poses a risk of suicide at this stage.

Table 23. Summary of RCTs Evaluating The Treatment of Central Post Stroke Pain

Author PEDro Score	n	Intervention	Main Outcome(s) Result
Vestergaard et al. 2001 8 (RCT)	30	lamotrigine vs. placebo (8 wk cross-over study)	Median Pain Score (+)
Attal et al. 2002 8 (RCT)	15	IV morphine vs. saline (2 wk cross-over study)	Visual Analog Scale (-)
Serpell et al. 2002 8 (RCT)	9 (with stroke)	Up to 2400 mg/day of gabapentin vs. placebo	Visual Analog Scale (+)
Lampl et al. 2002 7 (RCT)	39	Amitriptyline treatment vs. placebo	Visual Analog Scale (-)
Rowbotham et al. 2003 7 (RCT)	81 (10 CPSP patients)	High-strength (0.75-mg) vs. low-strength (0.15-mg) capsules of μ -opioid agonist	Pain Reduction (+)

		levorphanol	
Leijon & Boivie 1989(b) 6 (RCT)	15	Amitriptyline vs. carbamazepine vs. placebo (4 wk cross-over study)	Pain Intensity (+) Comprehensive Psychopathological Rating Scale (-)
Attal et al. 2000 6 (RCT)	16	lidocaine or saline intravenous injections (3 wk cross-over study)	Visual Analog Scale (+)
Bainton et al. 1992 5 (RCT)	20	Naxolone vs. normal saline (2 wk cross-over study)	Visual Analog Scale (-) Verbal Pain Scores (-)
- Indicates non-statistically significant differences between treatment groups + Indicates statistically significant differences between treatment groups			

Conclusions Regarding the Treatment of Post Stroke Central Pain

The majority of cases appear to be largely intractable to treatment.

Based on the results from two RCTs, there is conflicting (Level 4) evidence that treatment with amitriptyline results in a reduction of pain post stroke. Based on the results from a single RCT, there is moderate (Level 1b) evidence that lidocaine treatment results in short-term (45 min) pain relief; however, the results are not maintained at six hours following treatment.

There is moderate (Level 1b) evidence that intravenous morphine induces analgesic effects on some components of central neuropathic pain syndromes, but only a minority of patients may benefit from long-term opioid treatment.

There is moderate (Level 1b) evidence that Lamotrigine may be an alternative to tricyclic antidepressants in the treatment of CPSP.

There is fair (Level 2) evidence that motor cortex stimulation can provide long-term effective pain relief.

There is limited (Level 2) evidence that selective serotonin reuptake inhibitor fluoxetine treatment is useful for the management of CPSP relatively early following stroke.

There is moderate (Level 1b) evidence that high-strength μ -opioid agonist levorphanol is effective in reducing pain in post-stroke patients.

There is limited (Level 2) evidence that passive range of motion exercises can prevent the development of CRPS.

References

- Ada L, Foongchomcheay A, Canning C. Supportive devices for preventing and treating subluxation of the shoulder after stroke. *Cochrane Database Syst Rev* 2005;CD003863.
- Ada L, Foongchomcheay A. Efficacy of electrical stimulation in preventing or reducing subluxation of the shoulder after stroke: a meta-analysis. *Aust J Physiother* 2002; 48(4):257-267.
- Ada L, Goddard E, McCully J, Stavrinou T, Bampton J. Thirty minutes of positioning reduces the development of shoulder external rotation contracture after stroke: A randomized controlled trial. *Arch Phys Med Rehabil* 2005;86:230-234.
- Agnew DS, Shetter AG, Segall HD, Flom RA. Thalamic pain. In Bonica J, Lindblom U, Iggo A (eds). *Advances in Pain Research and Therapy Vol. 5*, Raven Press, New York, 1983, p. 941-946.
- Ancliffe J. Strapping the shoulder in patients following a cerebrovascular accident (CVA): A pilot study. *Australian Journal of Physiotherapy* 1992;38:37-39.
- Andersen G, Vestergaard K, Ingeman-Nielsen M, Jensen TS. Incidence of central post-stroke pain. *Pain* 1995; 61:187-193.
- Appel C, Mayston M, Perry L. Feasibility study of a randomized controlled trial protocol to examine clinical effectiveness of shoulder strapping in acute stroke patients. *Clin Rehabil* 2011; 25(9):833-843.
- Ashford S, Turner-Stokes L. Management of shoulder and proximal upper limb spasticity using botulinum toxin and concurrent therapy interventions: a preliminary analysis of goals and outcomes. *Disabil Rehabil* 2009;31:220-226.
- Attal N, Brassuer L, Parker F, Chauvin M, Bouhassira D. Effects of Gabapentin on the Different Components of Peripheral and Central Neuropathic Pain Syndromes: A Pilot Study. *Eur Neurol* 1998;40:191-200.
- Attal N, Gaude V, Brasseur L, Dupuy M, Guirimand F, Parker F, Bouhassira D. Intravenous lidocaine in central pain: a double-blind, placebo-controlled, psychophysical study. *Neurology* 2000;54:564-574.
- Attal N, Guirimand F, Brasseur L, Gaude V, Chauvin M, Bouhassira D. Effects of IV morphine in central pain: a randomized placebo-controlled study. *Neurology* 2002;58:554-563
- Awerbuch GI, Sandyk R. Mexiletine for thalamic pain syndrome. *Int J Neurosci* 1990;55:129-133.
- Bainton T, Fox M, Bowsher D, Wells C. A double-blind trial of naloxone in central post-stroke pain. *Pain* 1992;48:159-162.
- Bender L, McKenna K. Hemiplegic shoulder pain: Defining the problem and its management. *Disability and Rehabilitation* 2001;23(16):698-705.
- Bennett GJ, Laird JMA. Central changes contributing to neuropathic hyperalgesia. In: Willis WD (ed), *Hyperalgesia and Allodynia*, Raven Press, New York, 1992, pp. 305-310.
- Bhakta BB, Cozens JA, Bamford JM, Chamberlain M. Use of botulinum toxin in stroke patients with severe upper limb spasticity. *J Neurol Neurosurg Psychiatr* 1996; 61:30-35.
- Bobath B. *Adult hemiplegia: Evaluation and assessment (3rd ed)*. Heinemann, London, 1990.
- Boivie J, Leijon G, Johansson I. Central post-stroke pain - a study of the mechanisms through analyses of the sensory abnormalities. *Pain* 1989;37:173-185 (a).
- Boivie J. Central pain. In P.D. Wall and R. Melzack (eds.) *Textbook of Pain*, Churchill-Livingstone, Edinburgh, 1994; pp. 871-902.
- Boivie J. Hyperalgesia and allodynia in patients with CNS lesions. In W.D. Willis Jr. (ed.), *Hyperalgesia and Allodynia*, Raven Press, New York, 1992, pp. 363-373.
- Boonsong P, Jaroenarpornwatana A, Boonhong J. Preliminary study of suprascapular nerve block (SSNB) in hemiplegic shoulder pain. *J Med Assoc Thai* 2009;92:1669-1674.

- Borisova Y, Bohannon RW. Positioning to prevent or reduce shoulder range of motion impairments after stroke: a meta-analysis. *Clin Rehabil* 2009;23:681-686.
- Bowsher D, Laheuerta J. Central pain in 22 patients: clinical features, somatosensory changes and CT scan findings. *J Neurol* 1985;232:237-297.
- Bowsher D. Stroke and central poststroke pain in an elderly population. *J Pain* 2001;2:258-261.
- Braun RM, West F, Mooney V, Nickel RL, Roper B, Caldwell C. Surgical treatment of the painful shoulder contracture in the stroke patient. *J Bone Joint Surg (Am)* 1971;53:1307-1312.
- Braus DF, Krauss JK, Strobel J. The shoulder-hand syndrome after stroke: a prospective clinical trial. *Ann Neurol* 1994; 36(5):728-733.
- Brooke MM, de Lateur BJ, Diana-Rigby GC, Questad KA. Shoulder subluxation in hemiplegia: effects of three different supports. *Arch Phys Med Rehabil* 1991;72:582-586.
- Canavero S, Bonicali V. Corical stimulation for central pain. *J Neurosurg* 1995;83:1117.
- Cantor FK. Phenytoin treatment of thalamic pain. *Br Med J* 1972; 4:590.
- Carr EK, Kenney FD. Positioning of the stroke patient: a review of the literature. *Int J Nurs Stud* 1992;29(4):355-369.
- Chaco J, Wolf E. Subluxation of the glenohumeral joint in hemiplegia. *Am J Phys Med* 1971; 50:139-143.
- Chae J, Yu DT, Walker ME, et al. Intramuscular Electrical Stimulation for Hemiplegic Shoulder Pain: A 12-Month Follow-Up of a Multiple-Center, Randomized Clinical Trial. *Am J Phys Med Rehabil* 2005;84:832-842.
- Chae J, Ng A, Yu DT, et al. Intramuscular electrical stimulation for shoulder pain in hemiplegia: does time from stroke onset predict treatment success? *Neurorehabil Neural Repair* 2007;21:561-567.
- Chae J, Jedlicka L. Subacromial corticosteroid injection for poststroke shoulder pain: an exploratory prospective case series. *Arch Phys Med Rehabil* 2009;90:501-506.
- Chantraine A, Baribeault A, Uebelhart D, Gremion G. Shoulder pain and dysfunction in hemiplegia: effects of functional electrical stimulation. *Arch Phys Med Rehabil* 1999;80:328-331.
- Chen B, Stitik TP, Foye PM et al. Central post-stroke pain syndrome: yet another use for gabapentin? *Am J Phys Med Rehabil* 2002; 81(9):718-20.
- Davis RA, Stokes JW. Neurosurgical attempts to relieve thalamic pain. *Surg Gynecol Obstet* 1966;123:371-394.
- Davis SW, Pestrillo CR, Eischberg RD, Chu DS. Shoulder-hand syndrome in a hemiplegic population: a 5-year retrospective study. *Arch Phys Med Rehab* 1977;58:353-355.
- Dean CM, Mackey FH, Katrak P. Examination of shoulder positioning after stroke: A randomised controlled pilot trial. *Australian Journal of Physiotherapy* 2000;46:35-40.
- de Boer KS, Arwert HJ, de Groot JH, Meskers CG, Mishre AD, Arendzen JH. Shoulder pain and external rotation in spastic hemiplegia do not improve by injection of botulinum toxin A into the subscapular muscle. *J Neurol Neurosurg Psychiatry* 2008;79:581-583.
- Dejerine J, Roussy G. La syndrome thalamique. *Rev Neurol* 1906; 14:521-532 (also see Wilkins RH, Brody IA. The thalamic syndrome. *Arch Neurol* 1969; 20:55).
- Dekker JH, Wagenaar RC, Lankhorst GJ, de Jong BA. The painful hemiplegic shoulder: effects of intra-articular triamcinolone acetonide. *Am J Phys Med Rehabil* 1997;76:43-48.
- Dubner R. Neuronal plasticity and pain following peripheral tissue inflammation or nerve injury. In: Bond MR, Charlton JE, Woolf CJ (eds). *Pain Research and Clinical Management, Vol. 4, Proc. VIth World Congress on Pain*, Elsevier, Amsterdam, 1991, pp.263-276.
- Faghri PD, Rodgers MM, Glaser RM, Bors JG, Ho C, Akuthota P. The effects of functional electrical stimulation on shoulder subluxation, arm function recovery, and

- shoulder pain in hemiplegic stroke patients. *Arch Phys Med Rehabil* 1994;75:73-79.
- Faghri PD. The effects of neuromuscular stimulation-induced muscle contraction versus elevation on hand edema in CVA patients. *J Hand Ther* 1997;10:29-34.
- Fields HL, Adams JE. Pain after cortical injury relieved by electrical stimulation of the internal capsule. *Brain* 1974; 97:169-178.
- Fitzgerald-Finch OP, Gibson II: Subluxation of shoulder in hemiplegia. *Age Ageing* 1975;4:16-18.
- Frese A, Husstedt IW, Ringelstein EB, Evers S. Pharmacologic Treatment of Central Post-Stroke Pain. *Clin J Pain* 2006;22(3):252-260.
- Garcin R, Lapresle J. Incoordination cerebelleuse du membre inferieur par lesion localisee dans la region intern du thalamus control-lateral. *Rev Neurol (Paris)* 1969; 120:5.
- Geurts A, Visschers B, van Limbeek J, Ribbers G. Systematic review of aetiology and treatment of post-stroke hand oedema and shoulder-hand syndrome. *Scan J Rehab Med* 2000;32:4-10.
- Gilmore PE, Spaulding SJ, Vandervoort AA. Hemiplegic shoulder pain: implications for occupational therapy treatment. *Can J Occup Ther* 2004; 71(1):36-46.
- Gonzales GR. Suicide in central pain patients. *Neurology* 1994;44(Suppl 2):A318.
- Gresham GE, Duncan PW, Staston WB, et al. Post-Stroke Rehabilitation Guideline Panel. Post-Stroke Rehabilitation. Clinical Practice Guidelilne No. 16 CAHCPR Publication No. 95-0662), Rockville, MD: U.S. Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research, May 1995.
- Griffin A, Bernhardt J. Strapping the hemiplegic shoulder prevents development of pain during rehabilitation: a randomized controlled trial. *Clin Rehabil* 2006; 20(4):287-295.
- Gustafsson L, McKenna K. A programme of static positional stretches does not reduce hemiplegic shoulder pain or maintain shoulder range of motion--a randomized controlled trial. *Clin Rehabil* 2006; 20(4):277-286.
- Hamamci N, Dursun E, Ural C, Cakci A. Calcitonin treatment in reflex sympathetic dystrophy: a preliminary study. *Br J Clin Pract* 1996; 50(7):373-375.
- Hanger HC, Whitewood P, Brown G, Ball MC, Harper J, Cox R, Sainsbury R. A randomized controlled trial of strapping to prevent post-stroke shoulder pain. *Clin Rehabil* 2000;14:370-380.
- Hansson P. Post-stroke pain case study: clinical characteristics, therapeutic options and long-term follow-up. *Eur J Neurol* 2004;11 Suppl 1:22-30.
- Hecht JS. Subscapular nerve block in the painful hemiplegic shoulder. *Arch Phys Med Rehabil* 1992;73:1036-1039.
- Hecht JS. The role of spasticity in hemiplegic shoulder pain and what to do about it. 57th Annual Assembly of American Academy of Physical Medicine and Rehabilitation, Orlando, Florida, November 17, 1995, pp. 248-255.
- Hurd MM, Farrell KH, Waylonis GW. Shoulder sling for hemiplegia: friend or foe? *Arch Phys Med Rehabil* 1974;55:519-522.
- Inaba MK, Piorkowski M. Ultrasound in treatment of painful shoulder in patients with hemiplegia. *J Phys Ther* 1972;52:737-741.
- Jensen TS, Lenz FA. Central post-stroke pain: a challenge for the scientist and the clinician. *Pain* 1995;61:161-164.
- Johnstone M. The stroke patient: Principles of rehabilitation. Churchill Livingstone, Edinburgh, 1982.
- Joynt RL. The source of shoulder pain in hemiplegia. *Arch Phys Med Rehabil* 1992;73:409-413.
- Katayama Y, Fukaya C, Yamamoto T. Poststroke pain control by chronic motor cortex stimulation: neurological characteristics predicting favourable response. *J Neurosurg* 1998;89:585-581.
- Katayama Y, Yamamoto T, Kobayashi K, Kasai M, Oshima H, Fukaya C. Motor Cortex Stimulation for Post-Stroke Pain:

- Comparison of Spinal Cord and Thalamic Stimulation. *Stereotact Funct Neurosurg* 2001;77:183-186.
- Kalita J, Vajpayee A, Misra UK. Comparison of prednisolone with piroxicam in complex regional pain syndrome following stroke: a randomized controlled trial. *QJM* 2006;99:89-95.
- Kobayashi H, Onishi H, Ihashi K, Yagi R, Handa Y. Reduction in subluxation and improved muscle function of the hemiplegic shoulder joint after therapeutic electrical stimulation. *J Electromyogr Kinesiol* 1999;9:327-336.
- Kondo I, Hosokawa K, Soma M, Iwata M, Maltais D. Protocol to prevent shoulder-hand syndrome after stroke. *Arch Phys Med Rehabil* 2001; 82(11):1619-1623.
- Kong KH, Neo JJ, Chua KS. A randomized controlled study of botulinum toxin A in the treatment of hemiplegic shoulder pain associated with spasticity. *Clin Rehabil*. 2007;21:28-35.
- Koog YH, Jin SS, Yoon K, Min BI. Interventions for hemiplegic shoulder pain: systematic review of randomised controlled trials. *Disabil Rehabil* 2010;32:282-291.
- Koppel BS. Amitriptyline in the treatment of thalamic pain. *South Med J* 1986;79:759-761.
- Koyuncu E, Nakipoglu-Yuzer GF, Dogan A, Ozgirgin N. The effectiveness of functional electrical stimulation for the treatment of shoulder subluxation and shoulder pain in hemiplegic patients: A randomized controlled trial. *Disabil Rehabil* 2010;32:560-566.
- Kumar R, Metter EJ, Mehta AJ, Chew T. Shoulder pain in hemiplegia. The role of exercise. *Am J Phys Med Rehabil* 1990; 69(4):205-208.
- Kumar B, Kalita J, Kumar G, Misra UK. Central poststroke pain: a review of pathophysiology and treatment. *Anesth Analg* 2009;108:1645-1657.
- Lamp C, Yazdi K, Roper C. Amitriptyline in the prophylaxis of central poststroke pain. Preliminary results of 39 patients in a placebo-controlled, long-term study. *Stroke* 2002; 33(12):3030-3032.
- Laske E, Gunduz B, Celik EC. The effects of local shoulder injections in hemiplegic shoulder pain. *Am J Phys Med Rehabil* 2009;88:805-814.
- Leijon G, Boivie J, Johansson I. Central post-stroke pain - neurological symptoms and pain characteristics. *Pain* 1989;36:13-25(a).
- Leijon G, Boivie J. Central post-stroke pain - a controlled study of amitriptyline and carbamazepine. *Pain* 1989; 36:27-36(b).
- Leijon G, Boivie J. Central post-stroke pain - the effect of high and low frequency TENS. *Pain* 1989;38:187-191(c).
- Levin AB, Ramirez LF, Katz J. The use of stereotaxic chemical hypophysectomy in the treatment of thalamic pain syndrome. *J Neurosurg* 1983;59:1002-1006.
- Lieberman JS. Hemiplegia: Rehabilitation of the upper extremity. In: Kaplan PE, Cerullo LJ (eds.): *Stroke Rehabilitation*. Stoneman, MA, Butterworth Publishers, p.95-117, 1986.
- Lim JY, Koh JH, Paik NJ. Intramuscular botulinum toxin-A reduces hemiplegic shoulder pain: a randomized, double-blind, comparative study versus intraarticular triamcinolone acetate. *Stroke* 2008;39:126-131.
- Linn SL, Granat MH, Lees KR. Prevention of shoulder subluxation after stroke with electrical stimulation. *Stroke* 1999;30:963-968.
- Loh L, Nathan PW, Schott GD. Pain due to lesions of central nervous system removed by sympathetic block. *Br Med J* 1981; 282:1026-1028.
- Lynch D, Ferraro M, Krol J, Trudell CM, Christos P, Volpe BT. Continuous passive motion improves shoulder joint integrity following stroke. *Clin Rehabil* 2005;19:594-599.
- Marco E, Duarte E, Vila J et al. Is botulinum toxin type A effective in the treatment of spastic shoulder pain in patients after stroke? A double-blind randomized clinical trial. *J Rehabil Med*. 2007;39:440-447.
- Margolis LH, Gianascol AJ. Chlorpromazine in thalamic pain syndrome. *Neurology* 1956; 6:302-304.
- Mark VH, Ervin FR, Yakolw PI. Correlation of pain relief sensory loss and anatomical

- lesion sites in pain patients treated by stereotactic thalamotomy. *Trans Ann Neurol Assoc* 1961;86:86-90.
- Massagli TL, Cardenas DD. Immobilization hypercalcemia treatment with pamidronate disodium after spinal cord injury. *Arch Phys Med Rehabil* 1999;80:998-1000.
- Miley DP, Abrams AA, Atkinson JH, Janowsky DS. Successful treatment of thalamic pain with apomorphine. *Am J Psychiatry* 1978;135:1230-1232.
- Mok E, Woo CP. The effects of slow-stroke back massage on anxiety and shoulder pain in elderly stroke patients. *Complement Ther Nurs Midwifery* 2004;10:209-216.
- Moodie NB, Brisbin J, Morgan AM. Subluxation of the glenohumeral joint in hemiplegia: Evaluation of supportive devices. *Physiotherapy Canada* 1986;38:151-157.
- Morin L, Bravo G. Strapping the hemiplegic shoulder: A radiographic evaluation of its efficacy to reduce subluxation. *Physiotherapy Canada* 1997; 49:103-108.
- Moseley GL. Graded motor imagery is effective for long-standing complex regional pain syndrome: a randomised controlled trial. *Pain* 2004;108:192-198.
- Mucke L, Maciewicz R. Clinical management of neuropathic pain. *Neurol Clin* 1987; 5(4):649-662.
- Nandi D, Smith H, Owen S, Joint C, Stein J, Aziz T. Peri-ventricular grey stimulation versus motor cortex stimulation for post stroke neuropathic pain. *J Clin Neurosci* 2002;9(5):557-561.
- Nashold BS, Wilson WP, Slaughter DG. Stereotaxic midbrain lesions for central dysesthesia and phantom pain: preliminary report. *J Neurosurg* 1969;30:116-126.
- Nuzzo J, Warfield C. Thalamic pain syndrome. *Hosp Pract* 1985; Aug 15, p 32c-j.
- Paci M, Nannetti L, Rinaldi LA. Glenohumeral subluxation in hemiplegia: An overview. *J Rehabil Res Dev* 2005; 42(4):557-568.
- Pagni CA. Central pain and painful anaesthesia. *Prog Neurol Surg* 1977; 8:132-257.
- Pagni CA. Central pain due to spinal cord and brainstem damage. In Wall PD, Melzack R (eds). *Textbook of Pain*, Churchill Livingstone, London, 1984, p. 481-495.
- Partridge CJ, Edwards SM, Mee R, Van Langenberghe HV. Hemiplegic shoulder pain: a study of two methods of physiotherapy treatment. *Clinical Rehabilitation* 1990;4:43-49.
- Pertoldi S, Di BP. Shoulder-hand syndrome after stroke. A complex regional pain syndrome. *Eura Medicophys* 2005;41:283-292.
- Poduri KR. Shoulder pain in stroke patients and its effects on rehabilitation. *J Stroke Cerebrovasc Dis* 1993;3:261-266.
- Price CI, Pandyan AD. Electrical stimulation for preventing and treating post-stroke shoulder pain: a systematic Cochrane review. *Clin Rehabil* 2001;15:5-19.
- Quisel A, Gill JM, Witherell P. Complex regional pain syndrome underdiagnosed. *J Fam Pract* 2005;54:524-532.
- Renzenbrink GJ, IJzerman MJ. Percutaneous neuromuscular electrical stimulation (P-NMES) for treating shoulder pain in chronic hemiplegia. Effects on shoulder pain and quality of life. *Clin Rehabil* 2004;18:359-365
- Rizk TE, Christopher RP, Pinals RS, Salazar JE, Higgins C. Arthrographic studies in painful hemiplegic shoulders. *Arch Phys Med Rehab* 1984;65:254-55.
- Rowbotham M, Twilling L, Davies PS, Reisner L, Taylor K, Mohr D. Oral Opioid Therapy for Chronic Peripheral and Central Neuropathic Pain. *N Engl J Med* 2003;348:1223-32.
- Serpell MG. Gabapentin in neuropathic pain syndromes: a randomised, double-blind, placebo-controlled trial. *Pain* 2002;99:557-566.
- Segatore M. Understanding central post-stroke pain. *J Neurosci Nurs* 1996;28(1):28-35.
- Shimodozono M, Kawahira K, Kamishita T, Ogata A, Tohgo S, Tanaka N. Reduction of Central Poststroke Pain with the Selective Serotonin Reuptake Inhibitor Fluvoxamine. *Intern J Neuroscience* 112;1173-1181.
- Shin BC, Lee MS. Effects of aromatherapy acupressure on hemiplegic shoulder pain

- and motor power in stroke patients: a pilot study. *J Altern Complement Med*. 2007;13:247-251.
- Snels IA, Beckerman H, Twisk JW, Dekker JH, Peter DK, Koppe PA, Lankhorst GJ, Bouter LM. Effect of triamcinolone acetonide injections on hemiplegic shoulder pain : A randomized clinical trial. *Stroke* 2000;31:2396-2401.
- Sweet WH. Intracerebral electrical stimulation for the relief of chronic pain. In Youmans JR (ed). *Neurological Surgery* 2nd ed, W.B. Saunders, Philadelphia, 1982, p. 3739-3748.
- Tasker RR. Pain resulting from central nervous system pathology (central pain). In Bonica JJ (ed). *The Management of Pain*, Lea & Febiger, Malvern, PA, Vol 1, 2nd ed, 1990, p 264-283.
- Tourian AY. Narcotic responsive "thalamic" pain treatment with propranolol and tricyclic antidepressant. *Pain* 1987; (Supplement 4); 4:S411.
- Tyson SF and Chissim C. The immediate effect of handling technique on range of movement in the hemiplegic shoulder. *Clinical Rehabilitation* 2002;16:137-140.
- Vestergaard K, Andersen G, Gottrup H, Kristensen BT, Jensen TS. Lamotrigine for central poststroke pain: a randomized controlled trial. *Neurology* 2001;56:184-190.
- Vestergaard K, Nielsen J, Andersen G, Ingeman-Nielsen M, Arendt-Nielsen L, Jensen TS. Sensory abnormalities in consecutive, unselected patients with central post-stroke pain. *Pain* 1995; 61:177-185.
- Vick PG, Lamer TJ. Treatment of central post-stroke pain with oral ketamine. *Pain* 2001;92:311-313.
- Wall PD. Neuropathic pain and injured nerve: central mechanisms. *Br Med Bull* 1991; 47:631-643.
- Wang RY, Chan RC, Tsai MW. Functional electrical stimulation on chronic and acute hemiplegic shoulder subluxation. *Am J Phys Med Rehabil* 2000;79:385-390.
- White JC, Sweet WH. Pain and the Neurosurgeon. A Forty-Year Experience. Charles C. Thomas, Springfield IL, 1969, p. 386-406.
- Widar M, Alström G. Disability after stroke and the influence of long-term pain on everyday life. *Scand J Caring Sci* 2002;16:302-310.
- Widar M, Ek AC, Ahlstrom G. Coping with long-term pain after a stroke. *J Pain Symptom Manage* 2004;27:215-225.
- Williams R, Taffs L, Minuk T. Evaluation of two support methods for the subluxated shoulder of hemiplegic patients. *Phys Ther* 1988;68:1209-1214.
- Yamamoto T, Katayama Y, Hirayama T, Tsubokawa T. Pharmacological classification of central post-stroke pain: comparison with the results of chronic motor cortex stimulation therapy. *Pain* 1997;72:5-12.
- Yelnik AP, Colle FM, Bonan IV, Vicaut E. Treatment of shoulder pain in spastic hemiplegia by reducing spasticity of the subscapular muscle : A randomized, double-blind, placebo-controlled study of botulinum toxin A. *J Neurol Neurosurg Psychiatry* 2007;78 :845-848.
- Yu DT, Chae J, Walker ME, Fang ZP. Percutaneous intramuscular neuromuscular electric stimulation for the treatment of shoulder subluxation and pain in patients with chronic hemiplegia: a pilot study. *Arch Phys Med Rehabil* 2001;82:20-25.
- Yu DT, Chae J, Walker ME, Hart RL, Petroski GF. Comparing stimulation-induced pain during percutaneous (intramuscular_ and transcutaneous neuromuscular electric stimulation for treatment shoulder subluxation in hemiplegia. *Arch Phys Med Rehabil* 2001;82:756-60.
- Zorowitz RD, Idank D, Ikai T, Hughes MB, Johnston MV. Shoulder subluxation after stroke: A comparison of four supports. *Arch Phys Med Rehabil* 1995;76:763-771.