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Glenohumeral subluxation in hemiplegia: An overview

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Abstract—This review summarizes the recent advances in glenohumeral subluxation (GHS) in hemiplegic patients and analyzes the reliability and validity of clinical evaluation and the effectiveness of different treatment approaches. GHS, a common complication of stroke, can be considered an important risk factor for shoulder pain and other problems. GHS is a complex phenomenon, and its pathomechanics are not yet fully understood. Radiographic measurements are considered the best method of quantifying GHS. Clinical evaluation can be useful as screening assessment. Functional electrical stimulation and strapping are effective in an acute stage of hemiplegia; some types of slings have been shown to be effective and may be used together with other strategies.

Key words: assessment, hemiplegia, pathomechanics, physical therapy, rehabilitation, review, shoulder, slings, stroke, subluxation.

INTRODUCTION

The shoulder complex consists of four separate joints, which afford it incredible mobility in all planes of motion, but at the expense of its stability. The glenohumeral joint (GHJ) relies on the integrity of muscular and capsuloligamentous structures rather than bony conformation for its stability [1]. Injury or paralysis of muscles around the shoulder complex may lead to GHJ subluxation. Glenohumeral subluxation (GHS), a frequent complication for patients with a poststroke hemiplegia, is reported to be present in 17 to 81 percent of patients with hemiplegia following stroke [2], However, GHS's role in poststroke complications is still controversial. Although the impact of GHS on the development of shoulder pain (SP) and upper-limb functional recovery has not been completely explained, a number of authors [2–6] consider GHS an important source of SP. Moreover, several recent reviews focused on SP describe GHS management as the main intervention to prevent SP [2,5–6]. Thus, although GHS is probably the most cited problem causing shoulder complications after stroke, no paper is available that focuses directly on this problem and describes in detail the main aspects of the origin, assessment, or treatment of this frequent and poorly understood complication.

This paper intends to—

- provide an extensive overview on GHS,
- help explain its role in poststroke complications,
- report the reliability and validity of clinical evaluations, and
- summarize the effectiveness studies on its prevention and management.

Abbreviations: FES = functional electrical stimulation, GHJ = glenohumeral joint, GHS = glenohumeral subluxation, SP = shoulder pain.

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SEARCH STRATEGY

We systematically and electronically searched the literature from 1980 up to April 2004 to identify relevant trials for this review. We searched the MEDLINE® and EMBASE® databases using combinations of the key words “shoulder,” “subluxation,” “pain,” “stroke,” and “hemiplegia.” This research provided 53 articles in MEDLINE and 9 articles in EMBASE.

In addition, we manually searched reference lists and bibliographies of related journal articles and books for additional trials. Trials published before 1980 were included if they were helpful for the review (e.g., papers presenting a device for the first time). This additional research provided 20 articles (5 abstracts, 2 books or chapters of books, and 13 articles not indexed or published before 1980). The remaining references were papers known by the authors. We performed an additional literature research using the Cochrane Collaboration’s register and the key words “cerebrovascular disease” and “stroke rehabilitation.” We considered all studies in English, French, and Italian that concerned the incidence, origin, assessment, or treatment of GHS. Study design was not an exclusion criterion. However, studies on populations with diagnoses other than stroke were excluded.

DEFINITION

Different terms have been used to describe GHS characteristics: malalignment has been used to imply small signs of GHS [7] or inferior subluxation [8–9], and the term presubluxation, to describe few degrees of shifting [10] in contrast to major displacement. Typically, GHS has been described as inferior subluxation [11–16], but other patterns have been reported. Some authors describe the presence of anterior subluxation [17–19]; Ikai et al. found medial displacement of the humerus associated with inferior subluxation [20]. Ryerson and Levit report the presence of the anterior displacement [21], and Hall et al. described the superior subluxation due to increased tone in the trunk and scapula muscles [17].

In this review, GHS in hemiplegia is defined as each nontraumatic, partial or total change of relationship between the scapula and the humerus in all directions and in all planes, as compared with the nonaffected shoulder, that appeared after stroke.

INCIDENCE AND RESULTING COMPLICATIONS

Some researchers found an increased incidence of sympathetic reflex dystrophy of the upper limb associated with GHS [22–24], and others found a correlation between GHS and rotator cuff injury [8,25], overstretching of ligaments and muscles (supraspinatus and deltoid) [26], adhesive capsulitis [6] tendonitis, adhesions of the bicipital tendons [27], and rupture of ligaments [28]. Some investigations report dysfunction of the brachial plexus and other peripheral nerves in patients with GHS [25,29–30], but other studies have not found evidence of this dysfunction [6]. Several authors report a high correlation between subluxation and SP or arm pain [7,10,12,31–36], while others do not [11,13–15,20,37–38]. These inconsistent findings are due to the different assessment methods and times after the stroke occurred (**Table 1**).

An interesting observation is that most of the studies with conclusions of no relationship between GHS and SP were performed on smaller samples compared with the investigations that showed GHS as a risk factor for SP (trials: 7 vs. 10; mean sample size: 54 vs. 74.4, respectively). Another key point is the time from stroke onset: studies that report a correlation between GHS and SP have been performed in an acute stage of hemiplegia; the other studies frequently report a large range of time since stroke. Unfortunately, a number of authors [10,13–14,32,35] do not report information on time from the onset of the stroke, which seems to be an important factor for the origin of SP. In fact, SP changes with time, and its presence or seriousness could have a different incidence according to the stage of hemiplegia. For example, longitudinal investigations show a correlation between early signs of GHS and the development of SP [10,35].

Two mechanisms appear to be plausible explanations for why GHS may be considered a source of SP [15]. First, periarticular tissue may become overstretched, thereby causing pain, since the capsule and ligaments contain high concentrations of pain receptors. Second, overstretching may be the origin of painful ischemia in the tendons of the supraspinatus muscle and of the long head of the biceps muscle. This speculation is supported by a study showing that the subacromial area of the shoulder is a possible origin of pain [14]. SP may not be present in patients who have GHS, and may develop later. During the first stage of hemiplegia, GHS develops gradually if no trauma occurs, and the slow stretching does not

Table 1.
Relationship of shoulder subluxation to shoulder pain (SP). Population and study characteristics.

Author, Year [Ref.]*	No. of Subjects	Age (years)	Time After Stroke	Subluxation	Assessment	Relationship to SP
Najenson et al., 1971 [8]	32	NA	NA	26 (81%)	X rays (AP)	Yes
Shai et al., 1984 [10]	33	65.8 (38 to 85)	NA	19 (62%)	X rays (AP)	Yes
Crossen-Sills and Schenkman, 1985 [32]	21	NA	NA	NA	NA	Yes
Van Ouwenaller et al., 1986 [35]	219	NA (18 to 78)	NA	109 (50%)	X rays (AP)	Yes
Van Langenberghe and Hogan, 1988 [15]	44	65 (38 to 86)	13 (3 to 500) weeks	24 (54%)	X rays (AP)	No
Bohannon and Andrews, 1990 [11]	24	61 (33 to 84)	71 (11 to 511) days	9 (37%)	Clinical (palpation)	No
Poulin de Courval et al., 1990 [33]	94	68 (NA)	40 days	NA	X rays	Yes
Arsenault et al., 1991 [38]	40	46.5 (NA)	>3 months	19 (47.5%)	X rays (AP)	No
Joynt, 1992 [14]	67	NA	NA	21 (31%)	Clinical (palpation)	No
Ring et al., 1993 [34]	80	NA (34 to 78)	27 days (average)	45 (56%)	X rays (AP)	Yes
Cheng et al., 1995 [12]	50	62.1 (40 to 79)	3 weeks to 6 months	23 (46%)	Clinical	Yes
Roy et al., 1994 [7]	76	NA (41 to 99)	1 to 29 days	26 (34%)	X rays (AP)	Yes
Zorowitz et al., 1996 [37]	20	NA (42 to 83)	6 weeks	All	X rays (AP and 40°)	No
Wanklyn et al., 1996 [13]	108	71 (60 to 89)	NA	13 (29%)	Clinical (palpation)	No
Ikai et al., 1998 [20]	75	62 (35 to 83)	103 (20 to 376) days	All	X rays (AP)	No
Lo et al., 2003 [36]	32	64.2 (44 to 81)	NA	10 (44%)	Clinical (palpation)	Yes
Paci et al.†	107	NA (45 to 92)	15 days	52 (48.6%)	Clinical (palpation)	Yes

*References are listed in “References” section of main body text.
†Paci M, Nannetti L, Baccini M, Pasquini J, Rinaldi LA, Taiti PG. Shoulder subluxation after a stroke: relationships with pain and motor recovery. Physiother Res Int. Unpublished observations.
Note: Numbers in parentheses indicate range.
NA = not available (mean, range, or both), AP = anteroposterior view.

produce pain. Pain probably is present later after stroke because after subluxation, fibrous changes or injury can occur in the connective tissue of the ligaments and joint capsule because of the incorrect alignment between the humerus and the scapula. Besides its role in the development of SP, GHS has demonstrated to be an independent factor influencing arm motor recovery.*

In conclusion, GHS can be considered one of several potential sources of SP, it can be present alone or together with other problems [27,39], and it should always be treated early after stroke onset.

*Paci M, Nannetti L, Baccini M, Pasquini J, Rinaldi LA, Taiti PG. Shoulder subluxation after a stroke: relationships with pain and motor recovery. Physiother Res Int. Unpublished observations.

PATHOMECHANICS AND RISK FACTORS

In 1959, Basmajian and Bazant offered a theory to explain the development of GHS [40]. During the flaccid stage, the trunk tends to lean or shorten toward the hemiplegic side, which causes the scapula to descend from its normal horizontal level. The trapezium and the serratus anterior also become flaccid, causing the scapula to rotate downwardly. Without normal tone, the rotator cuff can no longer maintain the integrity of the GHJ. These conditions contribute to a subluxing GHJ [6,41–42]. During the spastic stage, the pectoralis major and minor, rhomboideus, elevator scapulae, and latissimus dorsi can become hypertonic, further rotating the scapula downward, causing GHS [41].

Researchers and clinicians have accredited these theories for many years. Recently little evidence of a relationship between scapular orientation and GHS has been found [18,43–44]. Prevost et al. assessed 50 stroke patients without finding any association between GHS and a downward orientation of the scapula [18]. Ikai et al. report the presence of GHS in only 1 out of 52 patients who had downward scapular rotation [43]. Similar results have been shown by Culham et al. [44] in a 34-patient sample and by Price et al., who assessed 30 stroke patients [45]. One can speculate that only damaged muscular function is responsible for GHJ integrity loss.

In confirmation to Griffin's review [6], recent investigations suggest a higher incidence of GHS in patients with complete or severe arm hemiplegia [20,33,46],* and Brunnstrom's arm motor stage has been shown to be a significant predictor of GHS [24]. Also Daviet et al. report motricity, assessed by the motricity index, as a factor related to GHS [47]. On the contrary, Zorowitz et al. found no correlation between Fugl-Meyer scores and vertical subluxation [48]. Recently, Zorowitz found spontaneous reductions of GHS in patients with significant motor recovery [49].

Chang et al. consider sensory impairment a precipitating factor for GHS development [24]; on the contrary, Daviet et al. found no significant correlation between sensory impairment and GHS ($p = 0.06$) [47]. Unilateral spatial neglect has been shown not to be associated with GHS [33,47].

Several authors [6,50] suggest that other factors contributing to subluxation include improper positioning, lack of support in the upright position, and pulling on the hemiplegic arm when the patient is transferred.

ASSESSMENT

Radiographic measurements, which are considered a standard measurement, have been used in several studies to assess the effectiveness of therapy or development of GHS over time. Generally, the X ray approach has been shown to be reliable [18–19] and valid [19]. Three different main methods measure GHS with the use of X rays: the anteroposterior view [17,51], the plane of the scapula method (at 30° to the coronal plane) [19,52–53], and the calculation of three-dimensional distances by two X rays (at 0° and at 45° or at 30° to the coronal plane) [18,20]. Splitting the radiographical data into categories [15] has been shown not to be a reliable method [54]. However, several problems, such as costs, exposure to radiation, or delayed feedback for therapeutic choices, make measurements difficult to put into practice in many clinical settings [17]. Moreover, some radiographic methods require specialized equipment that is not widely available.

Three simple methods to measure GHS in clinical practice are reported in the literature:

- Palpation. The use of palpation of the space between the acromion and the head of the humerus to measure GHS is described by some authors [11,25,41]. Cailliet suggests the use of palpation as an assessment of whether or not subluxation exists [41]. Some authors use fingers' breadth to measure subluxation. The size of the space is quantified by how many fingers can be placed between the acromion and the humerus. Bohannon and Andrews proposed to use the thumb as measurement [11], grading subluxation as none (0), minimal (1), or substantial (2).
- Anthropometrical evaluation that measures the distance in centimeters with a caliper [18] or a tape [17].† This measure is used to quantify the distance between a point on the acromion and a more distal point. Some authors use as a distal landmark the lateral epicondyle of the humerus [41,51]; others use the head of the humerus [55].
- Anthropometrical evaluation that measures distance with a thermoplastic jig [56].‡ The jig is an L-shaped device constructed of thermoplastic material (Plexiglas) with a tape measure, visible from only one side, embedded in the jig and a sliding beaklike marker that can be anchored with a thumbscrew. Landmarks are the same as the anthropometrical evaluation that uses a tape or a caliper.

*Paci M, Nannetti L, Baccini M, Pasquini J, Rinaldi LA, Taiti PG. Shoulder subluxation after a stroke: relationships with pain and motor recovery. Physiother Res Int. Unpublished observations.

†Cromwell S. Reliability of a simple device used to measure shoulder subluxation in hemiplegia. Paper presented at the meeting of the Spaulding Rehabilitation Hospital. National Stroke Rehabilitation Conference: Boston (MA); April 1991.

‡Ritt B, Belkin J, Lal S. Comparative study of sling supports for the subluxed hemiplegic shoulder (RT-20 Project R-109). Rehabilitation Institute of Chicago: Chicago (IL); 1980.

The reliability and validity of clinical measures of GHS have been established in several studies [11,19,51,55–56],*† (**Tables 2–4**). The literature examination shows moderate reliability and validity for the use of clinical measures to quantify the severity of GHS. Clinical evaluation can be useful as screening assessment [17,57], especially for an evident subluxation since we are not able to find early or less evident signs of GHS [10,38,57]. However, palpation has shown to have higher reliability and validity as compared with other clinical methods [2,57].

*Cromwell S. Reliability of a simple device used to measure shoulder subluxation in hemiplegia. Paper presented at the meeting of the Spaulding Rehabilitation Hospital. National Stroke Rehabilitation Conference, Boston (MA); April 1991.

†Ritt B, Belkin J, Lal S. Comparative study of sling supports for the subluxed hemiplegic shoulder (RT-20 Project R-109). Rehabilitation Institute of Chicago, Chicago (IL); 1980.

PREVENTION AND MANAGEMENT

Although the importance of GHS among poststroke complications is still controversial, emphasis has been placed on reducing GHS, and several studies were aimed

Table 2.
Shoulder subluxation measures. Interrater reliability.

Measure	Author, Year [Ref.]*	No. of Subjects	No. of Raters	Analysis	Results
Palpation	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.77 to 0.89
	Bohannon and Andrews, 1990 [11]	24	2	*k*	91.7% (*k* = 0.900)
Anthropometry (with caliper/tape)	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.77 to 0.79
	Cromwell, 1991†	NA	NA	*r*	0.93
	Manzo, 2001 [55]	10	2	ICC	0.68
Anthropometry (with jig)	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.26 to 0.53
	Hayes and Sullivan, 1989 [56]	10	2	ICC	0.74
	Manzo, 2001 [55]	10	2	ICC	0.75 and 0.83

*References are listed in "References" section in main body text.
†Cromwell S. Reliability of a simple device used to measure shoulder subluxation in hemiplegia. Paper presented at the meeting of the Spaulding Rehabilitation Hospital. National Stroke Rehabilitation Conference, Boston (MA); April 1991.
ICC = interclass correlation coefficient, *k* = Cohen kappa coefficient, *r* = Spearman correlation coefficient, NA = not available.

Table 3.
Shoulder subluxation measures. Intrarater reliability.

Measure	Author, Year [Ref.]*	No. of Subjects	No. of Raters	Analysis	Results
Palpation	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.90 to 0.94
Anthropometry (with caliper/tape)	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.81 to 0.95
	Cromwell, 1991†	NA	NA	*r*	0.94
	Manzo, 2001 [55]	10	2	ICC	0.53
Anthropometry (with jig)	Boyd and Torrance, 1992 [19]	36	4	ICC	From 0.51 to 0.84
	Hayes and Sullivan, 1989 [56]	10	2	ICC	0.89
	Manzo, 2001 [55]	10	2	ICC	0.71 and 0.77

*References are listed in "References" section of main body text.
†Cromwell S. Reliability of a simple device used to measure shoulder subluxation in hemiplegia. Paper presented at the meeting of the Spaulding Rehabilitation Hospital. National Stroke Rehabilitation Conference: Boston (MA); April 1991.
ICC = interclass correlation coefficient, *r* = Spearman correlation coefficient, NA = not available.

Table 4.
Shoulder subluxation measures. Validity.*

Measure	Author, Year [Ref.]†	No. of Subjects	Results
Palpation	Prevost et al., 1987 [51]	50	0.723
	Boyd and Torrance, 1992 [19]	36	From 0.268 to 0.695
	Hall et al., 1995 [17]	20	0.76
Anthropometry (with caliper/tape)	Prevost et al., 1987 [51]	50	0.747
	Boyd and Torrance, 1992 [19]	36	From 0.023 to 0.729
	Hall et al., 1995 [17]	20	0.46
Anthropometry (with jig)	Boyd and Torrance, 1992 [19]	36	From 0.084 to 0.486
	Hall et al., 1995 [17]	20	0.42
	Hayes and Sullivan, 1989 [56]	10	From 0.796 to 0.995

*Analysis used Spearman correlation.
†References are listed in "References" section of main body text

at its treatment. Although a large variety of physical treatments have been described in the literature, we have grouped them in the main different therapeutic approaches with their experimental reference studies.

Mechanical Approaches

Positioning

Several authors have proposed treating GHS with the limb positioned while patients lie in bed or with supportive devices while the patients are in the sitting position. Usually, for patients in bed, the arm is supported by a pillow [58], while for those in a wheelchair, a number of supports have been described [59–60]. Although no definitive evidence is available on positioning, the U.S. Clinical Practice Guideline reports strong consensus among experts on these two forms of positioning [61]. Two authors investigated the efficacy of lapboards and found, respectively, an acceptable reduction of GHS (less than 5 mm compared with the healthy shoulder) [62] and an overcorrection of inferior displacement [52].

Slings

A number of slings and other supports with different characteristics, design, and function have been described in the literature [41,58–59,63–67], but few studies have assessed their effectiveness in reducing GHS (**Table 5**). Findings from a few studies are as follows:

- Zorowitz et al. tested the effectiveness of four different slings in reducing GHS [48]. They found that the only sling that significantly corrected vertical asymmetry was the single-strap hemisling, while total asymmetry was corrected mostly by the Rolyan sling.
- Brooke et al. compared the Harris hemisling, the Bobath sling, and an arm trough/lapboard to assess their efficacy in reducing GHS [52]. Even though improved GHS was found in some cases, no sling that was used consistently prevented subluxation in all cases.
- In a study by Kieran et al., three different slings were compared in a group of 10 stroke patients [68]: the standard hemisling, the Bobath clavicular sling, and the modified vertical arm sling. The hemisling was found to be better in decreasing vertical and lateral GHS.
- Patterson et al. found that, when correctly applied, all five slings used in their study were effective in reducing GHS (Dennison sling, Dumbbell sling, Harris hemisling, Hook hemiharness, and Zimmer Fashion arm sling) [69].
- Williams et al. showed the Bobath sling and the Henderson sling to be effective and similar in correcting GHS [70].
- Moodie et al. assessed the effectiveness of five supports [62]. Two supports used in the sitting position in a wheelchair and the triangular sling (in standing) were effective; the Bobath roll and the Hook hemiharness were not effective in reducing GHS.

In all these studies, the efficacy of slings and supports was assessed when the device was put on the

Table 5.
Treatment of shoulder subluxation. Slings and other supports.

Author, Year [Ref.]*	No. of Subjects	Measurement	Supports	Results (cm)	Conclusions
Patterson et al., 1984 [69]	15	X rays (vertical)	Dennison sling	NA	Effective
			Dumbbell sling	NA	Effective
			Harris hemisling	NA	Effective
			Hook hemiharness	NA	Effective
			Zimmer Fashion arm sling	NA	Effective
Kieran et al., 1984 [68]	10	X rays (45° CP) (vertical and horizontal)	Standard hemisling	NA	Effective
			Bobath sling	NA	Ineffective
			Modified vertical arm sling	NA	Ineffective
Moodie et al., 1986 [62]	5	X rays (AP) (vertical)	Lapboard	–0.16	Effective (overcorrection)
			Arm trough	0.07	Effective (overcorrection)
			Triangular sling	–0.02	Effective
			Bobath roll	0.64	Ineffective
			Hook hemiharness	0.98	Ineffective
Williams et al., 1988 [70]	26	X rays (AP) (vertical)	Henderson shoulder ring	0.88	Effective
			Bobath sling	0.82	Effective
Brooke et al., 1991 [52]	10	X rays (AP) (vertical and horizontal)	Harris hemisling	–0.07 (V)	Effective
				0.16 (H)	Ineffective
			Bobath sling	0.47 (V)	Ineffective
				0.66 (H)	Ineffective
			Lapboard	–0.78 (V)	Effective (overcorrection)
				0.06 (H)	Ineffective
Zorowitz et al., 1995 [48]	20	X rays (AP) (vertical and horizontal)	Single-strap hemisling	0.34 (V)	Effective
				0.0 (H)	Effective
			Bobath sling	0.62 (V)	Effective
				0.49 (H)	Ineffective
			Rolyan humeral cuff sling	0.58 (V)	Effective
				0.15 (H)	Effective
			Cavalier support	0.90 (V)	Ineffective
				0.46 (H)	Ineffective
Morin and Bravo, 1997 [72]	15	X rays (45° CP) (vertical)	Conventional sling	0.68	Ineffective
			Strapping	0.42	Ineffective
			Sling + strapping	–0.06	Effective (overcorrection)

*References are listed in “References” section in main body text.
AP = anteroposterior view, CP = on the coronal plane, H = horizontal, V = vertical, NA = not available.

patient's shoulder; no investigation assessed the effectiveness of slings in relation to the duration of their use.

Supports have various purposes: realigning scapular symmetry, supporting the forearm in a flexed arm position, improving anatomic alignment with an auxiliary support, or supporting the shoulder with a cuff. The use of slings has been considered a contraindication by some authors because slings can facilitate an increase in flexor tone and synergistic patterns, cause reflex sympathetic dystrophy [71], restrain functional recovery, obstruct arm swing during walking, and for some, impair body image [2,48]. On the other hand, slings are generally more simple for caregivers to use than functional electrical stimulation (FES) or strapping, and they can be combined with the other treatments [72–73]. Reviewing the literature and knowing the structural characteristics of slings can help identify the best treatment for preventing and treating GHS. The just-mentioned contraindications, or criticism, should be addressed only to slings that support the forearm in the flexed arm position. In addition, slings for realigning scapular symmetry are of no use because no relationship between scapular orientation and GHS exists, and auxiliary supports have shown to have little effect on vertical GHS as well as increasing lateral displacement. Therefore, humeral cuff supports seem to give the best cost/benefit ratio.

However, when prescribing a sling, one should consider the characteristics and needs of each patient given that the same type of support may have different effects, as shown by different results in literature, intertrial and intratrial.

Strapping

Shoulder strapping has been shown to be useful in the first period after stroke [4,72,74]. Morin and Bravo found strapping to be more effective when it is combined with a conventional sling, as compared with the sling or strapping alone, especially in the first 3 to 5 days [72]. However, strapping alone was less effective than the sling alone (36% vs. 42% reduction). Two investigations assess the effectiveness of shoulder strapping in reducing SP [74–75]. In a small pilot study, Ancliffe showed that strapping delayed the onset of SP by 15 days in eight hemiplegic patients [74]. However, the author reports a high incidence of hygiene problems and skin reactions with strapping. Hanger et al. report a low incidence of skin problems, but also no significant benefit from using shoulder strapping, even if trends occurred for less pain and better arm function [75]. Each author uses a different strapping technique. The long-term effects of strapping on GHS should be investigated because taping may increase muscular activities [75–76]. For this reason, effects on spasticity should also be fully examined.

Neuromuscular Approach: Electrical Stimulation

FES is used to treat GHS from a stroke on the basis of two main effects: (1) muscle conditioning and (2) increase of muscle force and voluntary control ability [73]. Muscles that are usually treated are the supraspinatus and the posterior deltoid muscle because they play a fundamental role in maintaining correct alignment of the GHJ [42,76]. Usually [77–80], FES is performed with the use of rectangular balanced electrical current (frequency of 35–50 Hz) at an intensity that permits elevation of the humerus associated with slight abduction and extension, a discharge/pause ratio (on/off) that is gradually incremented from 1:1 to 15:1 over a span of 6 weeks. The duration of the treatment session is slowly increased from 1.5 hours to 6 hours daily 5 days a week for 6 weeks.

In a large investigation including subjects with chronic subluxation, Baker and Parker showed a significant reduction of GHS with FES [81]. Faghri et al. compared the effects of FES and physiotherapy alone in a group of hemiplegic patients affected by GHS for less than 4 weeks [77]. They reported that treatment with FES, as just described, significantly improved the range of painless joint movement and reduced GHS, as measured by targeted radiography. The results after 6 weeks of treatment were partially maintained at follow-up examination 12 weeks later.

Chantraine et al. [78] studied a large sample of patients with GHS for less than 1 month in which one-half received conventional therapy (orthotic) and the other half received conventional therapy plus FES. Follow-up examinations conducted at 6 months, 1 year, and 2 years after therapy showed that, compared with the group that received conventional therapy, in the group treated with conventional therapy plus FES, the management of pain was better, the number of patients with radiological evidence of subluxation had decreased significantly, and motor recovery had significantly improved. The best performances of the FES-treated group were also maintained at a follow-up after 24 months.

Kobayashi et al. showed a significant improvement in shoulder subluxation with FES of the deltoid and supraspinatus muscles [82]. Although segmental muscle force had also increased, the results were not statistically significant. Linn et al. report the effectiveness of FES in preventing GHS, but the effects of the treatment were not maintained at 4 and 12 weeks [79].

In a study by Wang et al., conventional therapy was compared with FES in the treatment of GHS in acute (stroke onset less than 1 month) and chronic (stroke onset more than 1 year) hemiplegic patients [80]. FES was found to be effective only in the treatment of subluxed patients with recent hemiplegia. In addition, a second treatment program gave no benefit to each group.

According to a recent meta-analysis, the literature shows that FES is effective in preventing GHS in an acute stage, but ineffective in reducing GHS in chronic patients [83] (**Table 6**). Moreover, FES seems to be more effective than orthotic therapy during the first weeks after the onset of stroke [73]. No definitive evidence supports FES as effective in reducing SP [84], and little information is available about FES's effects on motor recovery [78,80,82].

Intramuscular neuromuscular electrical stimulation has also been shown to be useful in decreasing GHS and SP, as well as in improving motor function in the hemiplegic upper limb [85–86].

Facilitation of Movement

No data are available on the efficacy of treating GHS with facilitation of movement. We can speculate that recovery of motor function helps reduce GHS. In fact, a number of studies suggest a higher incidence of GHS in patients with complete or severe arm hemiplegia [20,33], although Zorowitz et al. found no correlation between Fugl-Meyer scores and vertical subluxation [48]. Later, in a sample of 10 stroke patients, Zorowitz et al. found that motor recovery can influence the reduction of GHS [49].

CONCLUSION

Literature data suggest that FES and strapping are effective, especially in the acute stage of hemiplegia; similarly, some types of slings have shown to be effective and may be used together with other strategies.

Table 6.
Treatment of shoulder subluxation. Electric stimulation.

Author, Year [Ref.]*	Population	Design	Treatment	Measurement	Follow-up	Results
Baker and Parker, 1986 [81]	*N* = 63 acute and chronic	RCT	—	—	3 months	Effective
Faghri et al., 1994 [77]	*N* = 26 acute	RCT	6 weeks (6 hours a day)	X rays (AP)	3 months	Effective
Chantraine et al., 1999 [78]	*N* = 120 acute	RCT	—	—	6 months, 1 and 2 years	Effective
Kobayashi et al., 1999 [82]	*N* = 17	RCT	—	—	3 months	Effective
Linn et al., 1999 [79]	*N* = 40 acute	RCT	4 weeks	X rays (AP)	8 weeks	Effective (not in follow-up)
Wang et al., 2000 [80]	*N* = 32 chronic = 16 acute = 16	A-B-A† design	6 weeks (5 sessions/week)	X rays (AP)	No	Effective for acute patient
Yu et al., 2001 [86]	*N* = 8 chronic	Before-after trial	6 weeks	X rays (AP)	3 months	Effective

*References are listed in "References" section of main body text.
†Experimental design where the authors apply the treatment A (functional electrical training [FES] training), then the treatment B (routine therapy without FES training), and again the treatment A (FES training).
AP = anteroposterior view, RCT = randomized controlled trial.

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