The Effect of Dynamic Functional Shoulder Orthoses on the Development of a Shoulder-Hand Syndrome (SHS) Following a Stroke
Review of Evidence-based Studies
Stroke is a common disease and a significant cause of permanent impairment. Due to paralysis of the arm, many stroke patients develop a shoulder subluxation, a painful shoulder, or a shoulder-hand syndrome (SHS). This review provides answers to the key question of whether the use of shoulder orthoses can significantly prevent or reduce subluxation and shoulder-hand syndrome after a stroke. A selective literature search was conducted in PubMed. The results show that improving SHS was addressed only in a clinical study by Hartwig et al. Significant clinical improvement was found for the Neuro-Lux® (Sporlastic GmbH, Nürtingen) functional shoulder orthosis. The studies discussed came to contradictory results regarding improvement of subluxation and pain perception, which can be explained by the different study designs and different design and function of the orthoses used.

Key words: functional shoulder orthoses, shoulder-arm syndrome, shoulder-hand syndrome, shoulder subluxation, stroke

Introduction

Cardiovascular diseases are among the most common causes of death around the world. According to estimates of the World Health Organization, approx. 17.5 million people died as a result of cardiovascular diseases in 2012, around 6.7 million of them due to a stroke [1]. In Germany, around 1 million individuals are currently living with the consequences of a stroke, with around 270,000 more added each year. Around 50% of those who survive suffer permanent impairment and are dependent on support, assistance, and devices. Because stroke is primarily a disease of the elderly (> 65 years) and due to demographic developments, a considerable increase in those affected can be expected in the decades to come [2-5].

In addition to impaired speech, vision, and perception, hemiparesis is one of the most common results of a stroke [4]. To restore or improve the ability to walk, the focus has long been on neuroorthopaedic care of foot and leg paresis. A wide range of different devices are available for this indication. However, patients with a subluxated and painful shoulder, which can be a secondary result of a central arm paresis, often do not receive adequate care [6-9]. This is despite the fact that a painful shoulder occurs in 15%-40% of all those affected and is thus quite a common symptom. The cause is insufficient muscular stability in the shoulder joint due to weakened muscles. As a result, a change in the the position of the scapula and caudal movement of the humerus (subluxation) often occur, causing tension in the capsular ligament complex [10, 11].

Because of the resulting shoulder-hand syndrome (SHS) rate after shoulder subluxation – approx. 18% of those suffering from hemiparesis [12] – Koike et al. studied the underlying changes in skin temperature between patients with a shoulder-hand syndrome and an unimpaired control group [13, 14].

Davis et al. report that painful shoulders and oedematous wrists are often seen in combination with paresis-related limitation of mobility, while the elbow is not affected [13]. In view of these limitations of mobility, patients are predestined to develop flexion contractures of the hand and fingers in the long term without specific treatment [15].

Key question

Are functional orthoses for the shoulder joint available that can significantly prevent shoulder subluxation and the potentially resulting shoulder-hand syndrome (SHS) after a stroke?

Material and methods

A selective literature search was made using the search terms “shoulder-hand syndrome stroke orthosis”, “shoulder subluxation stroke orthosis”, “shoulder-hand syndrome stroke orthoses”, “shoulder subluxation stroke orthoses”, “shoulder-hand syndrome stroke brace”, “shoulder subluxation stroke brace”. All articles up to 10 February 2017 were included.

Results

A total of 21 articles about “shoulder subluxation and specific treatment options” were identified. Of these, 20 articles dealt only with the treatment of shoulder subluxation without the shoulder-hand syndrome and were therefore not included in addressing the key question.

Only the clinical study by Hartwig et al. examined the use of a special shoulder subluxation orthosis in connection with SHS. The study included patients who had had a fresh ischaemic stroke (0-21 days) confirmed by CT scan who were mobilised at least four hours per
day. Twenty patients were randomised and assigned to the intervention group classified according to the dominant hand. The control group included 21 patients. Patients in the intervention group were given a functional shoulder orthosis (Neuro-Lux®, Sporlastic GmbH, Nürtingen) in addition to standard treatment (physiotherapy and occupational therapy) (Fig. 1) [16, 17].

Pain and hyperalgesia, distal oedema, pain-free passive abduction, and external rotation in the shoulder were assessed using the shoulder-hand syndrome score by Braus et al. [18] at the start of the study and on days 7, 14, 21, and 28. In addition, anthropometric measurements of subluxation (without orthosis) and measurements of muscle strength (Medical Research Council [19]) were made. The patients in the intervention group were also asked to assess the wearing comfort of the orthosis and report the average daily wearing time. The averaged SHS score on days 14, 21, and 28 was significantly lower in the intervention group than in the control group (2.7 ± 1.5 vs. 4.8 ± 2.1; p < 0.0001) (Fig. 2) [17].

Muscle strength was comparable in the two groups, as was anthropometric measurement of subluxation after taking off the functional shoulder orthosis [17]. In summary, significant clinical effectiveness of the functional shoulder orthosis with respect to reducing SHS was found.

Discussion

Stroke is a common disease that causes a variety of limitations and impairments. One common complication of flaccid paralysis of the upper limb is the development of SHS, which is associated with a poor outcome. The relevance of this secondary disease is also reflected in scientific studies [13, 14].

The first systematic studies of the painful shoulder after a stroke or traumatic brain injury were conducted back in the 1970s. Krempen et al. emphasise that there are many causes of a painful shoulder in neurological diseases. In the cases where the painful shoulder occurred in conjunction with a subluxation, effective pain relief was achieved using a conventional neck sling [20]. Static systems of this type are still used today for immobilisation, e.g. after anterior or posterior shoulder dislocation (Fig. 3). [21].

However, during rehabilitation for arm paresis, immobilisation of the affected arm with a neck sling is problematic because it prevents effective therapy, fixes the arm to the body, and encourages learned non-use. Taking this criticism into account, Rajaram et al. developed a custom-made two-part shoulder orthosis that allowed movement of the affected arm while stabilising the shoulder [22]. Radiologic evidence of the reduction of subluxation was found when this shoulder sling was used. The authors also report a reduction of pain. However, no information was provided on the effect on the development or reduction of SHS.

Zorowitz et al. also studied the effect of different orthoses (“single-strap hemisling”, “Bobath roll”, “Rolyan humeral cuff sling”, “Cavalier support”) for a shoulder subluxation [23]. For the study, 20 stroke patients were provided with 4 different orthoses and the change in horizontal, vertical, and absolute asymmetry compared with the unaffected side was determined by radiologic analysis. Ultimately, an improvement of subluxation was found for all orthoses, although different orthoses had the best result for different

![Fig. 1 Neuro-Lux® II functional orthosis for stabilising the shoulder joint [16] (image shows the successor model of the tested orthosis).](image)

![Fig. 2 Change in the SHS score during treatment with and without a functional orthosis for stabilising the shoulder joint [17].](image)
patients. The authors concluded that fitting with an orthosis for shoulder subluxation must be customised for the individual patient. This study did not investigate other effects of the orthosis such as relieving pain or reducing SHS.

In 2002, Turner-Stokes and Jackson published a review which, among other things, studied the causes of developing a painful shoulder in patients with hemiplegia and the effectiveness of different treatment approaches [24]. In flaccid paralysis, subluxation due to the absence of muscular stability was identified as the cause of pain. In addition to cautious use of the affected arm and systematic interdisciplinary care, continuous support of the arm was considered to be essential. Functional electrical stimulation (FES) to activate muscles could also be important. It was not specified how continuous support of the arm should be implemented in practice. However, continuous support of the arm must be ensured not only when sitting, but also when the patient is mobilised when standing, walking, or during therapy. Consequently, merely positioning on a therapy table or immobilising the arm in a neck sling is neither sufficient nor useful.

Ayoyagi and Tsubahara also ascribe only a limited level of evidence to the use of shoulder slings and splints to reduce subluxation and call for additional randomised studies [25].

Ada et al. come to a similar conclusion. In a review, four studies were identified that investigated the effect of an orthosis on preventing subluxation, repositioning the humeral head, reducing pain, and improving the motor function of the shoulder after a stroke [26]. In summary, no clear evidence was found for the use of a shoulder sling. Taping the subluxated shoulder was the only method that appeared to delay the onset of pain. However, it did not reduce pain. The same working group reported in another study that the conventional neck sling was the orthosis most often used in practice, but that there was insufficient evidence regarding an improvement of subluxation [27]. Dajpratham et al. reach the same conclusion. They also found no significant reduction of shoulder subluxation when using two different neck slings [28]. By contrast, Hesse et al. found positive effects of a subluxation orthosis on gait and mobility. However, no reduction of pain was achieved with the subluxation orthosis used [29]. The study by Nadler et al. yielded similar data. It was shown that modern orthoses can effectively reduce subluxation. There is still insufficient evidence regarding a reduction of pain; no statement is made regarding the development of an SHS [30].

The results of the literature review thus identified only one clinical study that examined the effect of a functional shoulder orthosis in connection with SHS. According to the manufacturer’s information, the Neuro-Lux® orthosis is indicated for shoulder subluxation and to reduce SHS [16, 17]. Hartwig et al. found significant clinical effectiveness of the Neuro-Lux® functional shoulder orthosis for reducing existing SHS. This means that the Neuro-Lux® is currently the only orthosis that can effectively reduce a shoulder subluxation (Fig. 4) [17] while allowing free movement of the arm and thus facilitating effective therapy.

**Conclusion**

Further studies are needed to verify the effect of dynamic functional shoulder orthoses on shoulder subluxation and the development of shoulder-hand syndrome. The at times contradictory results of the available studies that were discussed do not yet allow a conclusive evaluation to be made, which is certainly also a result of the different designs and mode of action of the orthoses. However, the tendency is that more recent studies show evidence of positive results with modern orthoses. The aim should be the effective and evidence prevention of SHS through the use of contemporary materials and specific dynamic product details in the orthosis design.

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References:


