Physiotherapeutic treatment and clinical evaluation of shoulder disorders

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1 INTRODUCTION

Shoulder disorders in general

The incidence of shoulder complaints in Dutch general practice has been estimated at 12 to 25/1000/year.[2] The point prevalence of shoulder disorders in the general population of 25 years and older in the Netherlands is 20.9%, the period prevalence during 12 months is 30.3% while the prevalence of chronic shoulder pain is 15.1%.[2] The age group 42–46 years both males and females has the highest risk of suffering from a painful shoulder.[3] Most patients with severe shoulder complaints experience an improvement within 2 weeks while 50% of the patients are cured within 6 weeks. Nevertheless, after one year approximately 40% of the patients still suffer from shoulder complaints.[4] The clinical guideline on shoulder complaints of the Dutch College of General Practice distinguishes between patients with or without restrictions in shoulder motion.[5] Referral to a physical therapist is not advisable during the first 6 weeks of a new episode of shoulder complaints, because the clinical course is often benign and the general practitioner can treat with analgesics and local injections, if needed. After 6 weeks, referral can be considered for complaints clearly causing limitations of daily functioning. Despite this wait and see policy in the Netherlands, patients with shoulder disorders are the third largest group of musculoskeletal conditions that are referred to physical therapy in primary healthcare.[6] General practitioners refer 5% of the patients with shoulder complaints to specialists in hospitals.[7] Little is known about the nature and severity of these shoulder complaints in patients consulting the institutional health care. Although many shoulder disorders are considered to be self-limiting, the medical, social and economical burden appears to be large.

Shoulder complaints include a wide variety of conditions and diseases. They originate mostly from intrinsic causes (articular or periarticular) while a minority has extrinsic causes (disorders from the cervical spine, neurological disorders, vascular disorders, neoplasms or referred pain from internal organs). The diagnosis of shoulder complaints is difficult due to the complex interactions between the shoulder, shoulder girdle, cervical and thoracic spine. In the early stages of shoulder complaints many symptoms are similar and therefore do not discriminate between diagnoses. Different pathologies often coexist at the shoulder, either as a consequence of shared causes, or because the presence of one disorder predisposes to another.[8] Moreover, the lack of generally accepted criteria for shoulder disorders adds to the confusion.[3]

In this thesis we will focus on the physical therapy and evaluation of a particular disorder of the shoulder, the frozen shoulder (synonymous with adhesive capsulitis of the shoulder).*

Historical overview of the frozen shoulder

Duplay first describes the symptoms in 1872 using the term 'peri-arthrite scapulo-humerale'.[9] Codman's extensive knowledge of shoulder pathology is compiled in his book 'The Shoulder' (1934).[10] Codman gave a more detailed description of this shoulder

* These two terms are used interchangeable in literature. In this chapter the term 'frozen shoulder' is used.

condition and introduced the term 'frozen shoulder'. He also put his doubts about the entity of this disorder by quoting the historic words: 'it's hard to define, it's hard to treat and it's difficult to understand from the viewpoint of pathology'. His pendulum exercises are still used in the treatment of many shoulder disorders. [10] J. Neviaser coined the term 'adhesive capsulitis' after open surgery in affected shoulders. He observed a sound like adhesive tape being pulled off when he manipulated the adhered capsule of the shoulder.[11]

Lundberg was the first to distinguish between primary and secondary frozen shoulders. The primary frozen shoulder has no precipitating cause. A secondary frozen shoulder can have multiple causes varying from an upper limb trauma, hemiplegia, ischaemic heart diseases, pulmonary tuberculosis, chronic bronchitis, epilepsy, diabetes mellitus to hyper- or hypothyroidism. [12–14] It can also be associated with Dupuytren's or Parkinson's disease.[15] Even trivial trauma has been postulated as a possible cause of a frozen shoulder. Despite this list of possible concomitant diseases the majority of cases are idiopathic. Some authors consider prevention to be the best management for pa - tients in high risk groups prone to develop a secondary frozen shoulder. [16–19] Jorgensen claims that, due to the insidious nature of primary frozen shoulders, prevention is not possible.[20]

A frozen shoulder is, in general, regarded as self-limiting. Reeves pointed out that frozen shoulders have a tendency to resolve within two to three years without any form of treatment.[21] Long-term follow-up showed little functional impairment despite some restriction of movement in 40%[22] to 50%[23] of the patients.

T. Neviaser in 1987 defined four stages of a frozen shoulder based on arthroscopic observations: stage1: mild synovial inflammation that is detectable especially in and around the axillary fold of the joint capsule; stage 2: acute synovitis with adhesion of the dependent folds of the synovial lining; stage 3: maturation of the adhesions with little inflammation; stage 4: chronic adhesions. [24]

Rowe (1988) defined three clinical phases of this disorder. First a 'freezing' phase in which pain increases after an insidious onset and is apparent over a period ranging from a few weeks to nine months. Active range of movement is limited due to pain. In the second phase, the 'frozen' phase, pain decreases and the shoulder becomes more and more stiff, passive mobility decreases and pain is less in the foreground. This phase may last from 4 to 9 months. In the 'thawing' phase the shoulder mobility returns gradually.[25]

The clinical guideline on shoulder pain of the American Academy of Orthopaedic Surgeons describes the following definition of the frozen shoulder: 'Frozen shoulder (adhesive capsulitis) is a condition of uncertain aetiology characterised by significant restriction of both active and passive shoulder motion that occurs in the absence of another known intrinsic shoulder disorder.'[26]

In this thesis, it was decided to use the classification by Rowe and more specifically the second phase because this phase comprises clear and practical elements reflecting the capsular restrictions of the glenohumeral joint. We have worded the definition as follows:

'Frozen shoulder, the second phase of an adhesive capsulitis, is a common disorder of the glenohumeral joint, which is characterised by a disease duration of more than 3 months and

a multidirectional limitation of passive movements of more than 50% in the glenohumeral joint in abduction, forward flexion and / or external rotation.'

Epidemiology and aetiology of the frozen shoulder

The cumulative risk for at least one period of a frozen shoulder for people within the age group of 35 – 74 years has been estimated at 2%[12]; the exact prevalence and incidence are unknown. It is most common between 40 and 60 years whereas the frequency in females is slightly higher than in males. [13,16] The prevalence of a frozen shoulder in adults of working age (25–64 years) was found to be 8.2% among men and 10.1% among women.[8] Developing a frozen shoulder on the contralateral side is not unusual after an episode of a frozen shoulder, while 14 % of all these cases present simultaneously. Up to 80% of the bilateral cases will occur within 5 years of the initial episode. [27] Recurrence in the same shoulder is seldom.

The prevalence of a frozen shoulder in patients with diabetes mellitus increases to 10–20% and for patients with insulin-dependent diabetes mellitus even up to 50%. [12,28,29]

Pathology of the frozen shoulder

In patients with a frozen shoulder the first phase, with pain and decreased active joint mobility, is followed by a prolonged period of stiffness. This suggests a sequential capsulitis with an inflammatory synovial process followed by fibrosis of the glenohumeral joint capsule. The decreased range of motion (ROM) is thought to be due to a compact arrangement of collagen fibres and fibroplasia in the joint capsule. [12,30] It takes some time for capsular collagen tissue to turn over into a less elastic and less dynamic structure.[31,32–34]

Schollmeier[31] investigated the effects of immobilization (after 12 weeks) and remobilization (after 12 weeks of immobilization) in glenohumeral joints of beagle dogs. Decrease in volumetric capacity of the joint, and impairment of motion in conjunction with adhesion formation, showed that immobilization produced similar effects on the glenohumeral joint as seen in frozen shoulders of humans. It would seem that the contraction of the capsule causing marked diminution in the joint volume probably was caused by a secondary mechanical effect of shrinking brought about by prolonged immobility of the joint, rather than by an increase in connective tissue. Prolonged immobilization does not induce permanent damage in the canine glenohumeral joint because the changes in the joint's movements, its volumetric capacity, and the capsular structure are almost completely reversed by the twelfth week of remobilization. [32]

Bunker and co-workers carried out histological and immunocytochemical studies on the contracted areas of the capsule in human shoulders. Based on these findings it seems likely that a frozen shoulder is initiated by one of a number of triggering factors that occur in patients with a predisposition to contracture. An inflammatory healing response appears to be produced within the capsule of the shoulder. This is moderated by cytokines and growth factors, leading to the accumulation and propagation

Figure 1.1 Girdle hunching manoeuvre in the affected right shoulder.

of fibroblasts which typically lay down an excess of type-III collagen. [35] A significant increase in fibroblasts and structural changes in connective tissue were also seen in the histological study of Kilian. [36] A loss of fibril order and a twisting of collagen fibrils were discernible. The cytokine response may also lead to angionesis within the capsule giving the typical arthroscopic appearances of frozen shoulder as described in the studies of Wiley and Uitvlugt. [37,38]

At the same time there may be a failure of collagen remodelling. In normal tissue the matrix metalloproteinases (MMPs) are zinc-dependent proteinases, which degrade the connective tissue matrix as part of a normal turnover. Specific tissue MMP inhibitors (TIMPs) and a variety of cytokines and growth factors control the synthesis and activity of the MMPs. Hutchinson et al postulated that a decrease in the MMP: TIMP ratio could cause an increased synthesis and deposition of collagen in the connective tissue leading to the development of a frozen shoulder. [39] The imbalance between aggressive healing, scarring, contracture and a failure of remodelling may lead to the protracted stiffening of the capsule. [35,40,41]

Clinical presentation of the frozen shoulder

Most authors consistently describe the symptoms of a patient with a painful stiff shoulder. The patients complain of a generalised aching in the shoulder, especially in the Deltoid region, but cannot pinpoint a specific area. The pain may radiate to the scapula or down the lateral aspect of the upper arm and, occasionally, to the forearm. The pain is more severe during the night with an inability to sleep on the affected shoulder. During the day, arm movements near the end-range of motion aggravate the pain. To overcome the impaired glenohumeral motion patients use accessory muscles and compensatory scapula rotation, showing a typical 'shoulder girdle hunching manoeuvre' when they elevate or abduct the arm. [16,17] (Figure 1.1)

Clinical evaluation in the first phase of a frozen shoulder is quite difficult due to the wide variability and the diffuse nature of the symptoms (e.g. pain in rest, during the

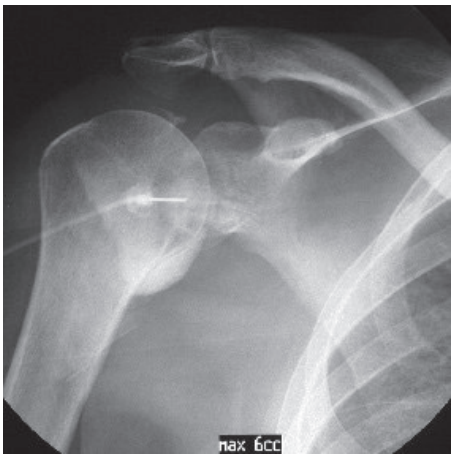

Figure 1.2 Arthrography of the right shoulder with a maximum capacity of 6 cc.

night or during activities) that can mimic other shoulder disorders as well. [42,43] In the first phase pain is felt before the end of the range of motion by passive movement can be reached. In the second phase the contracture of the capsule prevents normal rolling and gliding with the end-feel consisting of a hardish arrest of movement as if two pieces of rubber are squeezed together or a piece of thick leather is stretched. [44] Cyriax[44] described the typical capsular pattern of the glenohumeral joint in frozen shoulders with the abduction more limited than the external rotation, and external rotation more limited than the internal rotation. Mitsch et al [45] questioned the assumption that all patients suffering from a frozen shoulder possess the same pattern of limitation. He found that external rotation is significantly more limited than internal rotation and abduction. Joint play of the glenohumeral joint is severely limited. Active and passive glenohumeral motion is decreased by more than 50% in all planes. In the third phase the joint play increases and the end-feel normalises.

Only a few authors mentioned the degree of restriction of the glenohumeral movement necessary to make the diagnosis of a frozen shoulder. Kessel [46] described a study of 50 patients with a frozen shoulder fulfilling the minimal diagnostic criterion of a limitation of all shoulder movements by at least 50 per cent. In a prospective evaluation of 75 patients with an idiopathic frozen shoulder, Griggs [47] used the criterion of more than 50% loss of active and passive external rotation with the shoulder in 90° abduction while Brox[48] referred to a marked reduction (at least 50% of the contralateral shoulder) of glenohumeral outward rotation and abduction. [47,48]

In the first and second phase of the disease, according to Rowe, patients experience severe limitations in personal care and daily activities. Moreover it affects the ability to work and the participation in athletic and recreational activities. Limiting the use of the arm or moving within its free range relieves the pain and discomfort. In the third phase, as motion increases, there is a gradual restoration of function.

In longstanding cases mild atrophy in the deltoid and supraspinatus muscles can be observed. Strength testing in the midrange position of the glenohumeral joint is usually asymptomatic.

Diagnostic procedures for the frozen shoulder

When patients are admitted to institutional health care with the suspicion of a frozen shoulder an anterior-posterior radiograph of the shoulder is usually made to rule out other underlying pathology that can result in a painful stiff shoulder, such as fractures, osteoarthritis, malignancy, chondrocalcinosis, avascular necrosis, calcifying tendinitis and posterior luxation.[16,25,43,49] Radiographs in frozen shoulders are usually normal except for osteopenia associated with disuse and minor subcortical cystic changes. [50] Although a significant decrease in bone marrow density can be found in the humerus of the affected extremity in patients with a frozen shoulder, in the long term this bone loss shows good recovery.[51]

Arthrography can be used to confirm the diagnosis of a frozen shoulder. [21,52,53] A normal glenohumeral joint capsule contains more than 15 cc, in symptomatic shoulders the volume can easily be reduced to less than 5 cc. The characteristics of an arthrogram in frozen shoulders are a decreased glenohumeral joint volume due to obliteration of the axillary fold and subscapular bursa, absence of contrast in the biceps tendon sheet and a thickened capsule.(Figure 1.2)

Lundberg[12] reported a significant positive correlation between joint volume and total elevation in primary as well as secondary frozen shoulders. This is in contrast to later studies from Itoi[54] and Loyd[55] where the severity of the changes did not predict the degree of restriction of motion, nor it was directly related to the prognosis for clinical recovery. Magnetic Resonance Imaging with arthrography revealed a thickened coracohumeral ligament (CHL) and joint capsule in the Rotator Cuff interval, a smaller volume of the axillary recess and complete obliteration of the fat triangle between the CHL and the coracoid process. [56,57] In some shoulders a rupture of the Rotator Cuff can be observed in the symptomatic shoulder when the contrast leaks into the subacromial space. Observations by Reeves [21] revealed that small to medium size defects of the Rotator Cuff in frozen shoulders tend to heal by the process of obliteration.

Arthroscopy has been used in the evaluation of frozen shoulders with varied results.[58] Neviaser described adhesions in the dependent fold in contrary to Kilian who did not find intra-articular adhesions and no obliteration of the axillary recess. [36,59] However Kilian did find a notably contracted biceps tendon. [36] Laboratory tests on blood and immunological factors are mostly negative and therefore not considered as routine.[60] Technetium scanning has also been used diagnostically and the involved shoulder shows a diffuse technetium uptake, possibly secondary to hypervascularity. The findings are non-specific and have no correlation with the duration of symptoms, initial severity or recovery. [22,46,60]

Physical therapy and the frozen shoulder

The Dutch health care system consists of three levels. In the primary level, general health care is given by the family doctor and by various health professionals in private or group practices. The second level concerns care as provided in academic and non-academic hospitals or outpatient clinics. The third level consists of specialized clinics,

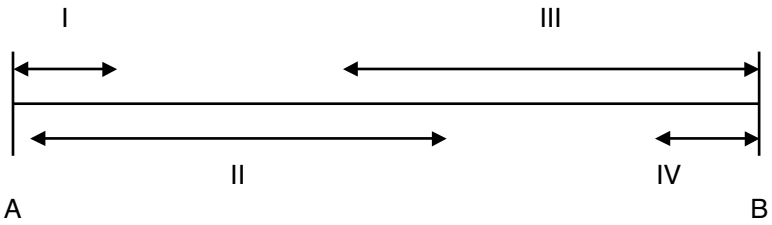

Figure 1.3 Grades of mobilization depicted on a line representing a normal range of motion (A – B).

Grade I: a tiny amplitude movement near the starting position of the ROM.
Grade II: a large amplitude movement which carries well into the range but does not reach the end of the ROM.
Grade III: a large amplitude movement which reaches the end of the ROM.
Grade IV: a tiny amplitude movement at the end of the ROM.
Grade V: manipulation or high-velocity thrust beyond the available ROM

rehabilitation centres or nursing homes. Dutch physical therapists (± 20,000) work in all three levels, most of them (11,000) in primary care (www.cbs.nl). A written referral of a medical doctor is necessary before treatment can be initiated, however a new system of direct access to physical therapy is in preparation for 2006.

In the Netherlands presumably most patients with a frozen shoulder are treated in primary care by family doctors and physical therapists (no numerical data available). In our experience, the more chronic or therapy-resistant patients are treated by physical therapists in outpatient departments of hospitals after referral by (orthopeadic) surgeons, rheumatologists or rehabilitation doctors.

Not all physicians advocate the use of physical therapy in the treatment of frozen shoulders. 'Supervised neglect' with analgesia and accepting the natural course of the disease has also been advised to patients (the 'patient' patient) in primary and institutional health care. [61,62]

The basic principles of the treatment of frozen shoulders are to relief pain, maintain range of motion and ultimately to restore full range of motion and function. [63–68] In the first phase of a frozen shoulder pain is on the foreground. Two authors advise to support the affected arm in the acute phase by means of a sling or collar & cuff. [25]

Treatment of a frozen shoulder by means of physical therapy can consist of different modalities (e.g. exercises, electrotherapy or massage) which can be applied side by side. Relief of pain by means of massage [23,69], (deep) heat[63,69–72], ice[69,73,74], ultrasound[70,73,75], Transcutaneous Electrical Nerve Stimulation (TENS) [16,74,75], magnetotherapy[71] or laser[76] are described in textbooks and papers concerning the treatment of frozen shoulder, however they probably offer little benefit. Mostly these applications are adjuvant to other treatment modalities like mobilization techniques or home exercise programs.

There are several studies regarding the effectiveness of the physical therapy in frozen shoulders (Table 1.1). In these studies a variety of physiotherapeutic treatment modali-

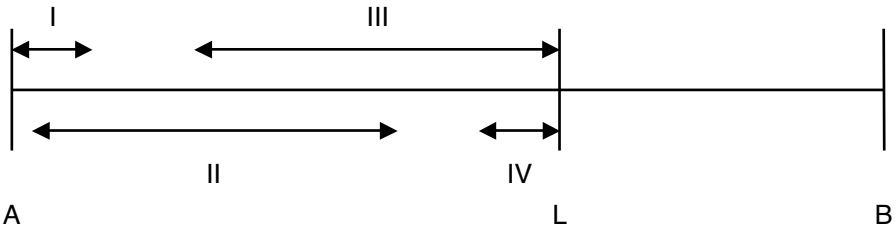

Figure 1.4 When pathology limits the range of movement (A – L) the grades are reduced in range.

ties are combined within one treatment group. As more than one treatment modality has been employed within the treatment groups, it is not possible to assign the results of the intervention to a single treatment modality. Moreover, the differences between the inclusion criteria highlight the lack of a uniform definition of the frozen shoulder. In 7 out 14 studies the total follow-up is ≤ 3 months. Regarding the outcome measures, most studies present their results on the level of body function and structure e.g. pain and ROM. Only a few studies use shoulder questionnaires or measures for quality of life. Although most studies report a positive effect for the physiotherapeutic interven - tions, due to methodological shortcomings it is impossible to draw firm conclusions about the therapeutic effects within these studies.

Mobilization techniques and the frozen shoulder

The mainstays of many programs for the treatment of frozen shoulders are mobiliza - tion techniques and (home-)exercises. [25,67,77]

Mobilization refers to a procedure that increases or maintains the mobility of the soft tissues (soft tissue mobilization) and/or the joints (joint mobilization). [33,78,79] Mobilization techniques of the joints were propagated by Mennell and Kaltenborn in the sixties and seventies of the last century, respectively. They distinguished angular and accessory movements of the joint. [78,80] A normal joint moves within its physiological range and the angular movements can be clinically documented externally by goniom - etry. The accessory or intra-articular bone motion takes place within the capsule of the joint and is divided into two basic types: spin (rotation) or swing (rolling and gliding). These are subtle motions that are performed by means of passive manual techniques and are used in the assessment of joint disorders. This passive, translatoric movement or accessory movement is referred to as 'joint play' when this is used as a test. This movement is present in all normal joints. In pathological joints the joint play and normal end-feel has altered. In stiff joints the end-feel of the capsular restraints can feel hardish. [44] The direction of this translatoric movement depends on the convex or concave shape of the joint partner that will be moved. [78] For example, the translatoric movement in the glenohumeral joint that corresponds with abduction in the frontal plane is a movement of the head of the humerus in a caudal-lateral direction. A third, non-physiological movement that can be assessed in a joint is traction: the two joint

Table 1.1 Overview of studies in patients suffering from a frozen shoulder with physical therapy alone as one of the treatment arms

First author	year	type	no. pt	Treatment period	Inclusion criteria
Lee[63]	1973	RCT	80	6 weeks	Pain limited passive ROM
Liang[70]	1973	prospective study	51	mean is 4 weeks for each group	stiffness active and passive limitation in abduction and rotations pain around the shoulder or radiation when the shoulder moves
Hamer[73]	1976	quasi-experimental	31	Mean: 5 weeks	pain limited passive ROM
Leclaire[71]	1991	RCT	47	3 months	pain >2 months limited active and passive ROM >20% in at least three movements pain at resistant abduction, internal or external rotation
Waldburger[74]	1992	RCT	50	Physiotherapy for 60 days (all patients), calcitonin for 21 days	<3months duration limited active and passive ROM (<20% ext rotation, <70% in flexion, <70% abduction)
Stenvers[69]	1994	retrospective multiple-subject study	53	mean 7 months	pain ROM <50% in all directions no trauma no other intrinsic disorder

Interventions	follow-up	Outcome measures	Author's conclusions
1. infra-red irradiation + graduated active exercises to patient's tolerance + PNF 2. intra-articular injection + same exercises 3. injection in synovial sheet in bicipital groove + same exercises analgesics	weekly for 6 weeks	ROM	All groups receiving exercise benefited significantly more than the analgesic group. No significant differences among the groups 1, 2 and 3.
1. intra-articular injection + heat therapy + exercises 2. intra-articular injection + exercises 3. heat therapy + exercises Heat=SWD, ultrasound and hot-pack	post treatment	ROM	Exercise is probably the only measure responsible for the functional restoration of the frozen shoulder. As a supplementary measure local steroids or local heat application is very helpful
1. cryotherapy + exercises 2. ultrasound + exercises	at discharge	pain rotational lack	In both groups patients improved . No significant differences between groups.
1. electromagnetic therapy + hot packs + passive + active exercises 2. sham electromagnetic therapy + hot packs + passive + active exercises	4, 8, 12 weeks	pain ROM disability	Similar improvement in both groups and no significant differences. Electromagnetic therapy has no positive influence.
1. active mobilization + TENS + cryotherapy 2. subcutaneous injections of salmon calcitonine + active mobilization + TENS + cryotherapy	1, 3, 8, 24 weeks	pain ROM	Significant reduction of pain in first 3 weeks in the combination group. In both groups increased mobility but no significant difference.
All patients: cold pack or infra red heat + massage + mobilizations	3–9 years after treatment	pain ROM strength satisfaction	Optimal physiotherapeutic treatment is cold pack or infra red heat + massage + mobilizations

Table 1.1 Overview of studies in patients suffering from a frozen shoulder with physi - cal therapy alone as one of the treatment arms (continued)

First author	year	type	no. pt	Treatment period	Inclusion criteria
Van der Windt[96]	1998	RCT	109	6 weeks	painful and limited passive gle - nohumeral mobility with lateral rotation relatively more limited than abduction and internal rotation
Griggs[47]	2000	prospective evaluation	75	?	no trauma >50% loss of external rotation pain at extremes of ROM limited glenohumeral translation normal findings on Rx
Liaw[88]	2000	prospective evaluation categorized in 4 groups of time since onset	35	2 months	soft tissue capsular lesion painful and restricted active and passive ROM
Sun[97]	2001	RCT	35	6 weeks	pain >1 and <12 months pain at night flexion <90°
Aydogan[75]	2003	prospective study	48	1 month	>3 months at least two findings of passive <100° abduction, <50° external rotation <70° internal rotation <140° elevation ->3 yrs diabetes mellitus type II
Guler[72]	2004	RCT	40	2 weeks	>2 months active and passive limitation >30 mm on VAS pain normal RX no other medical problems

RCT=randomized controlled trial, ROM=range of motion, PNF=Proprioceptive Neuromuscular Facilita - tion, SWD=short wave diathermy, SDQ=Shoulder Disability Questionnaire, FAQ=Functional Ability Questionnaire

Interventions	follow-up	Outcome measures	Author's conclusions
1. maximal 3 intra-articular injections 2. passive joint mobilization and exercise treatment	3, 7, 13, 26, 52 weeks	pain ROM improvement severity SDQ	Injections may be preferable to physiotherapy in the initial treatment of painful stiff shoulder
All patients: home exercises + physiotherapy program (content unknown)	6–12 weeks 12–41 months	pain ROM DASH SF-36	90% of patients considered the outcome of non-operative treatment to be satisfactory
All patients: active ROM exercises until point of pain	2 months	ROM FAQ	Patients may benefit from earlier physiotherapy
1. active stretching exercises 2. active stretching exercises + acupuncture	20 weeks	- Constant score	Combination of acupuncture and exercises may be an effective option.
1. patients with good glycemic control + no neuropathic symptoms 2. patients with poor glycemic control + neuropathic symptoms All patients: pulsed ultrasound + TENS + pendular, stretching and strengthening exercises	1, 3 months	pain ROM Constant score	In both groups pain decreased significantly while ROM and Constant score increased significantly. Poor glycemic control and neuropathy did not alter the therapeutic response of frozen shoulders to conservative treatment.
1. Cyriax deep friction + manipulation + active stretching + home exercises 2. SWD + hotpack, active stretching, home exercises	2 weeks	speed of recovery pain ROM	Cyriax method has faster and better response in early phase of adhesive capsulitis

Table 1.2 Overview of studies in patients suffering from a frozen shoulder and treated with mobilization techniques in one of the treatment arms

First author	year	type	no. pt	Treatment period	Inclusion criteria
Bulgen[86]	1984	RCT	42	6 weeks	painfull stiff >4 weeks restricted ROM and loss of full function pain at night
Nicholson[90]	1985	RCT	20	4 weeks	pain limited passive ROM
Dacre[95]	1989	RCT	62	6 weeks	painful stiff >4 weeks limited ROM and loss of full function pain at night
Maricar[91]	2000	RCT	32	5-8 weeks	late stage 2 to stage 3 major complaint is limitation of ROM able to place arm behind head and back had 90° abduction
Diercks[62]	2004	Quasi-experimental with succesive cohort as control	77	?	>50% restriction in all directions >3 months

RCT=randomized controlled trial, ROM=range of motion, PNF=Proprioceptive Neuromuscular Facilitation

partners are distracted by a subtle passive motion in order to relieve pain or to stress the periarticular tissue.

Maitland refined the techniques from Mennell and Kaltenborn and described five grades of mobilization, varying in amplitude and applied force depending on the purpose of the mobilization technique.[64] Grades I and II mobilizations are most often used for pain reduction. Grade III and IV are considered to increase ROM as the are applied towards the end of the available ROM. Grade V is a manipulation or high-velocity thrust beyond the available end ROM (Figures 1.3 and 1.4). Graded mobilizations are externally imposed, small-amplitude passive motions intended to produce gliding or traction at a joint. Mobilizations techniques applied at the end of the avail-

Interventions	follow-up	Outcome measures	Author's conclusions
1. steroid injections 2. Maitland mobilizations 3. ice + PNF 4. no treatment All: pendular exercises	Weekly for 6 weeks Monthly for 6 months	pain ROM	Improvements in all groups. Steroids may benefit pain and ROM in early stages. Little long-term advantage over no treatment.
1. mobilizations + active exercises 2. active exercises	1, 2, 3, 4 weeks	pain ROM	Only passive abduction improved significantly more in mobilization group.
1. local injection 2. physical therapy: mobilizations 3. combination 1 + 2	6 weeks and 6 months	pain ROM	No consistent differences between the treatment groups.
1. mobilizations + active exercises 2. active exercises	3, 5, 7, 8 weeks	ROM strength	Improvements in both groups. No significant additional effect of mobilizations to exercise therapy alone.
1. Supervised neglect (pendulum exercises, active exercise within pain) 2. passive mobilization and stretching	3 months interval to 24 months	ROM Constant score	Supervised neglect is superior to passive stretching with regard to functional end result and speed of recovery

able arthrokinematic range of motion are intended to elongate the connective tissue. The application of force to connective tissue during tissue healing and remodelling can improve the extensibility and strength of the tissue. [32,81–84] The minimal effective dosage of the force necessary to improve the function of the joint capsule has not yet been defined.[85]

End-range mobilization techniques are considered to play an important role in the treatment of frozen shoulders as they supposed to influence the capsular adhesions, treat the stiffness and subsequently increase the joint mobility. The joint is moved maximally into the restricted range of motion and in this position three-dimensionally adjusted. From this position traction- or gliding-mobilization is given in order to

produce a specific stretch to a certain part of the contracted capsule. The intensity and prolonged stretch depends on the patients' tolerance and must be guided by careful assessment.[64] Using a little traction during the gliding mobilizations will prevent the bony surfaces from compression and sheering forces.

However, some authors disagree with the intensive treatment of frozen shoulders. Bulgen even mentioned a possible detrimental effect of active physiotherapy in the acute stage and Rowe stated that exercises would only cause additional discomfort. [22]

There is no consensus about the intensity with which mobilization techniques or exercises should be performed. Some authors advise not to provoke pain in the shoulder during treatment and gentle movements of the shoulder joint should be performed. [25,86–88] Others propose a more vigorous method stretching the contracted capsule and treating the stiffness to the patient's tolerance. In these cases, patients should be instructed that this might result in a transient increase of discomfort, which would subside within a few hours after treatment has ended. [64,89]

Studies with mobilization techniques in frozen shoulders

In contrast to the importance attached to mobilization techniques in the treatment of frozen shoulders, studies describing mobilization techniques as a single intervention are scarce. Bulgen compared Maitland mobilizations with steroid injections, ice packs followed by Proprioceptive Neuromuscular Facilitation techniques and a no-treatment group in a randomized clinical trial (Table 1.2). After the first four weeks the largest improvements in ROM were seen in the steroid group. At six months there was little advantage in any of the treatment regimens over no-treatment. Bulgen stated after this study that there was little place for physical therapy alone and certainly not for treatment lasting longer than 4 weeks. [86]

Studies of Nicholson and Maricar both compared mobilization techniques with active exercises. Nicholson randomly assigned 20 patients with a painful stiff shoulder to either a group with active exercises and pendulum exercises or to a group with active exercises, pendulum exercises and passive gliding and distracting techniques towards the end of the range of motion. After 4 weeks only passive abduction in the group with passive mobilization techniques showed a significant difference. [90]

Maricar concluded from a randomized controlled trial (RCT) in 32 patients that adding manual therapy to a standard set of exercises did not demonstrate an additional improvement in the ROM in patients with stiff shoulders.[91] The studies of Nicholson and Maricar were characterized by small numbers of patients, a short follow up period, (4 and 8 weeks, respectively), and a high dropout rate of 40% in the study of Maricar.[90,91]

Although all the studies in Table 1.2 reported improvements in shoulder function, the small numbers of included patients in each treatment group, a short follow up period and methodological flaws (e.g. randomisation, blinding) does not allow for an evidence-based recommendation. Just as in the studies in Table 1.1, a uniform definition of the frozen shoulder was lacking and the main outcome measures were on the

level of body function and structure (pain and ROM) and not on the level of activities and participation. Moreover, no shoulder specific questionnaires were used.

Aim of the thesis

In the last decade there was a growing need for evidence to support or refute the efficacy of common interventions for shoulder pain.[16,48,66,68,79,92,93]

In this thesis a new approach with end-range mobilization techniques in the treatment of frozen shoulders is introduced and compared with a less intensive method.

Historically the main outcome measures in the evaluation of shoulder disorders, and frozen shoulders in particular, are range of motion and pain. Nowadays patient-oriented measures to determine the accompanying disability are regarded as at least equally important. The use is recommended of valid, reliable and responsive outcome measures on different levels of the International Classification of Functioning, Disability and Health (ICF)[2] in clinical trials concerning shoulder disorders.[94]

The aim of this thesis is to contribute towards a better understanding of treatment and assessment of patients with a frozen shoulder attending institutional health care and the clinical evaluation of patients with other shoulder disorders.

Outline of the thesis

Following the general introduction regarding the epidemiology, aetiology, assessment and treatment of the frozen shoulder in *Chapter 1* this thesis is divided into two parts:

Part I describes the results of the physiotherapeutic treatment of the frozen shoulder by means of mobilization techniques

Part II describes the clinical evaluation of the frozen shoulder and other shoulder disorders by various measurement instruments.

Part I Physiotherapeutic treatment of the frozen shoulder

Chapter 2 shows a multiple-subject case study in 7 patients with a unilateral frozen shoulder treated with end-range mobilization techniques. *Chapter 3* presents the results of a randomized controlled trial, comparing two treatmeant strategies with mobilization techniques in 100 patients with a unilateral frozen shoulder. In this trial we performed a cost-utility analysis comparing both mobilization techniques with respect to societal costs and quality-adjusted life years. Next a burden-of-illness study is presented estimating the impact of the frozen shoulder on costs and health. The results of this economic evaluation are presented in *Chapter 4*.

[2] ICF and ICD-10 (International Classification of Diseases and Related Health Problems, 10th revision) are the core of the World Health Organisation Family of International Classifications. (www.rivm.who-fic)

Part II Clinical evaluation of the frozen shoulder and other shoulder disorders

Chapter 5 describes a new method of measuring shoulder positions by means of a three-dimensional electromagnetic tracking system. In a group of 15 healthy volunteers, two observers performed repeated measurements to examine the inter-trial, inter-day, inter-observer and intersubject reliability. In *Chapter 6* the clinical application of the three-dimensional electromagnetic tracking device was tested on 10 patients with a unilateral frozen shoulder. The three-dimensional movement patterns of affected and non-affected shoulders were compared before and after 3 months treatment by means of end-range mobilization techniques.

The translation, adaptation and validation of the Shoulder Rating Questionnaire into the Dutch language is discussed in *Chapter 7* while the responsiveness of the Shoulder Function Assessment scale in 35 patients with rheumatoid arthritis suffering from shoulder complaints is presented in *Chapter 8*. *Chapter 9* describes a comparison between two portable dynamometers in the assessment of shoulder and elbow strength in order to determine the practical applicability and the measurement properties of both devices. Finally, in *Chapter 10*, the findings and conclusions of the preceding chapters are summarized and indications for further research are discussed.

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