Aspects of current management

THE ROLE OF SURGERY IN FROZEN SHOULDER

A. F. W. Chambler, A. J. Carr

From the University of Oxford, England

Frozen shoulder is a common disorder which is characterised by pain and loss of movement. Its cause is poorly understood and its management is disputed because of lack of supporting evidence.

Duplay,¹ in 1872, used the term “peri-arthritis scapulo-humeral” to describe the condition. In 1934, Codman² introduced the term frozen shoulder and set certain criteria for diagnosis and management. Neviaser³ used the term adhesive capsulitis to reflect his findings at surgery and at post-mortem. Zuckerman and Cuomo⁴ defined the condition as one of uncertain aetiology characterised by substantial restriction of both active and passive movement in the shoulder occurring in the absence of a known intrinsic disorder of the shoulder. The aetiology remains unknown, although some aspects of the pathophysiology have recently been documented.⁵ The symptoms are generally self-limiting over one to three years. The role of treatment which includes physiotherapy, analgesics, injection of cortisone, manipulation and surgical release, must be assessed in the context of a tendency to self-resolution. This review examines the evidence to support interventional procedures in treating this painful and often debilitating condition.

Epidemiology

Hannafin and Chiaia⁶ found the prevalence to be slightly greater than 2% in the general population. It is more common in women and between the ages of 40 and 60 years.^{5,7} Recurrence is unusual⁸ and both shoulders are affected in between 6% and 34% of cases.^{5,9,10}

Classification

This condition may be primary or secondary. Zuckerman and Cuomo⁴ have separated secondary into intrinsic, extrin-

Table I. Conditions associated with adhesive capsulitis in the literature

Authors	Condition
Stam ¹¹	Upper limb trauma
Arkkila et al ¹²	Diabetes
Choy et al ¹³	ACTH deficiency
Wohlgethan ¹⁴	Hyperthyroidism
Bowman et al ¹⁵	Hypothyroidism
Okamura and Ozaki ¹⁷	Reduced bone mineral density
Lundberg and Nilsson ¹⁸	Osteopenia
Tuten et al ¹⁹	Cardiac surgery
Pineda et al ²⁰	Cardiac catheterisation through the brachial artery
Bruckner and Nye ²¹	Neurosurgery
Patten and Hillel ²²	Radical neck dissection
Smith et al ²³	Dupuytren's disease
Riley et al ²⁴	Parkinson's disease
Boyle-Walker et al ²⁵	Cardiac disease
Wadsworth ²⁶	Pulmonary disease
Jayson ²⁷	Stroke
Bunker and Esler ²⁸	Hyperlipidaemia
Hutchinson et al ²⁹	Treatment with matrixmetalloproteinase inhibitor

sic and systemic categories. Table I¹¹⁻²⁹ highlights the known conditions or associations with this disease.

Natural history

The pattern is one of eventual recovery through three symptom-related phases. The initial phase is associated with an insidious onset of pain increasing in severity over a period ranging from a few weeks to nine months.^{6,9} During this ‘freezing’ phase, the shoulder loses active and passive movement. The second ‘frozen’ phase may last from four to nine months, during which the pain begins to abate leaving global stiffness of the shoulder. The final ‘thawing’ phase sees the return of movement towards normal over a period of five to 26 months. Codman² stated that recovery, even in severe cases, occurred in about two years and this view is supported by the study by Grey³⁰ in 1978, who reported that 24 of 25 patients treated conservatively returned to normal within a maximum of two years. Miller, Wirth and Rockwood³¹ found that there was return of movement and minimal residual pain in most of their 50 patients treated by a home rehabilitation programme. However, residual symptoms have been widely documented. Some 28 years ago, Reeves⁹ reported a prospective study of 49 patients with

A. F. W. Chambler, BSc, MS, FRCS Orth, Clinical Shoulder Fellow
A. J. Carr, MA, ChM, FRCS, Nuffield Professor of Orthopaedic Surgery,
Consultant Shoulder and Elbow Surgeon
Upper Limb Unit, Nuffield Orthopaedic Centre, Windmill Road, Headington, Oxford OX3 7LD, UK.

©2003 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.85B6.14379 \$2.00
J Bone Joint Surg [Br] 2003;85-B:789-95.

Fig. 1

Diagram of the natural history of adhesive capsulitis (A, patients not seeking medical attention; B, patients showing fast recovery; C, patients showing slow recovery).

idiopathic frozen shoulder, of whom 41 were available for follow-up after five to ten years. The mean duration of the condition was 30.1 months, but 61% had slight restriction of movement, although in only 6% was it felt to be a handicap. A prospective study of 40 patients in Cambridge using various treatments failed to show any difference from a control group over an eight-month period.³² Long-term follow-up showed little functional impairment at a mean of 44 months, although 40% had some restriction of movement of the shoulder.³³ However, there were three treatment groups and a control group which considerably reduced the power of the study. Shaffer, Tibone and Kerlan³⁴ also described a group of patients treated non-operatively with 50% having some pain or stiffness when seen at a mean follow-up of seven years. These objective findings did not relate to any significant functional disability. All these studies involved patients who had been referred to orthopaedic departments. Undoubtedly, there may be many who suffer a mild form of the condition but recover quickly and do not seek medical attention. Figure 1 gives the natural history from the information available in the literature.

Pathogenesis and cellular investigations

The aetiology remains unknown. There are associations with many medical conditions as seen in Table I, the strongest being that with diabetes in which the incidence is reported as being between two and four times higher than that in the normal population. Indeed, several authors have suggested that frozen shoulder may be an algoneurodystrophic process.³⁵⁻³⁹ The condition has only rarely been recorded in other joints including the wrist, hip, and ankle.⁴⁰⁻⁴⁴ There is one possible case reported in childhood.⁴⁵

The macroscopic pathological changes are of capsular contracture. Neviaser³ described four stages of the disease and these have been correlated with changes in the histological appearance.⁶ The disease process has also been shown to include contracture of the coracohumeral ligament.^{46,47} Microscopically, both inflammatory^{3,10,48} and fibrotic⁴⁹ processes have been described. However, the specific cellular basis for the pathology seen in frozen shoulder has not

been identified. A dense matrix of type-I and type-III collagen laid down by fibroblasts and myofibroblasts is seen. Lundberg⁵⁰ showed that there was an increase in glycosaminoglycans and a decrease in glycoproteins, specifically hyaluronic acid. Rodeo et al⁴⁸ studied cytokines and their receptors by immunolocalisation. Their results suggested that transforming growth factor beta and platelet-derived growth factor may be involved and act as a continual stimulus in the inflammatory and fibrotic process. Bunker et al⁵¹ examined the expression of growth factors, cytokines and matrix metalloproteinases (MMPs) in patients with frozen shoulder and compared this with Dupuytren's tissue and a control group. They recorded an imbalance between aggressive healing, scarring, contracture and a failure of remodelling which may lead to the protracted course of the disease. Immunological studies have failed to identify successfully a link with HLA-B27 or any specific autoimmune or arthritic process.^{10,52-54} Interestingly, patients treated with metalloproteinase inhibitors are reported to be prone to develop frozen shoulder and Dupuytren's contracture.⁵¹

Management of frozen shoulder

Conservative. Since the accepted prognosis is one of eventual resolution, a conservative approach is often followed. 'Supervised neglect' with analgesia, as required, was the basis of the early management and has given the only data concerning the natural history. Simple exercise programmes together with relatively non-invasive procedures, such as intra-articular injections, nerve blockade and hydrodistension have been introduced more recently and several studies are now available for review.

Miller et al³¹ reviewed retrospectively 50 patients (39 idiopathic) at a mean of three months after the onset of symptoms. An 'orthotherapy' rehabilitation programme was instigated. Functional movement (defined as painless movement to within 20° of the normal side) returned at a mean of 14 months (3 to 36). There appeared to be a bimodal distribution of recovery with one group achieving this within 12 months and the other between 15 and 24 months. There were, however, no true associations with the variables in the

Table II. Summary of results for manipulation for frozen shoulder

Author/s	Number of patients	Mean age (yrs)	Male:female ratio	Mean time of preop symptoms (mths)	Treatment*	Mean follow-up	Results
Haines and Hargadon ⁷⁴	78	57	37:41	2 to 6	MUA + steroid	12 wks	83% gaining 80% of G/H ROM before physiotherapy discharge
Hill and Bogumill ⁷⁵	14	51	1:1	5.4	MUA + steroid	22 wks	75% painfree
Weber et al ⁷⁶	43	52.8	16:27	6	MUA + inpatient physiotherapy	4.7 yrs	73% full recovery. Mean time off work after MUA 6.2 wks
Roubal et al ⁷⁷	8	44	1:1	7	G/H gliding manipulation with ISB	Not stated	6 patients successful in reducing pain + increasing movement
Andersen et al ¹⁶	24	46	11:13	8	Arthroscopy + MUA + physiotherapy with infusion of the subacromial bursa	Min 12 mths	75% normal ROM, 79% no pain
Placzek et al ⁷⁸	31	49.1	12:19	7.8	G/H gliding manipulation	14.4 mths	Significant gains in ROM and pain reduction
Dodenhoff et al ⁷⁹	37	53	10:27	8	MUA	11 mths	94% satisfied
Kivimaki and Pohjolainen ⁸⁰	24	51	1:1	7	MUA or MUA + steroid	4 mths	Equal results in both groups
Sharma et al ⁸¹	32	55.3	7:5	2 to 6	MUA (12)	35 mths	Significantly better results in distension group
		56.3	1:1		Distension with LA and steroid (20)	25.4 mths	
Pollock et al ⁸²	26	49	11:15	14	MUA + arthroscopy	31 mths	83% excellent or satisfactory
Melzer et al ⁸³	110	34-78	2:3	Not stated	Physiotherapy + drug (89) or MUA (21)	3.8 yrs	16.6% unsatisfied. Physiotherapy better than MUA
Ekelund and Rydell ⁸⁴	22	53	3:8	15	Distension with local anaesthetic and steroid and MUA	4 to 6 wks	91% no or slight pain, 83% normal or almost normal ROM
						4 yrs	Results maintained

*G/H, glenohumeral

patients' data. Griggs, Ahn and Green⁵⁵ also used a shoulder stretching exercise programme for phase-II idiopathic adhesive capsulitis in 75 consecutive patients. The mean duration of shoulder pain before evaluation was 9.2 months (1.3 to 47) and follow-up was for 22 months (12 to 41). A satisfactory outcome was seen in 90% of patients, with five of the seven who were unsatisfied undergoing manipulation under anaesthesia (MUA) and/or arthroscopic release. Both of these studies report follow-up within the range of recovery for the natural history documented by Reeves.⁹ While these regimes of treatment showed no detrimental effects, the conclusion as to whether treatment was beneficial, has to be somewhat speculative since there were no control groups in either study. In 1992, Shaffer et al³⁴ reported that in a series of 62 patients from an initial cohort of 183, 50% had pain or stiffness at a mean of seven years and 60% had restriction of movement. They had all undergone shoulder rehabilitation exercises supplemented by various treatment regimes, including subacromial injection (84%) and MUA (6.2%). The pain and stiffness were never more than mild and the restriction was "unrelated to subjective symptoms, infrequently affected the activities of daily living and caused little functional disability".

Nerve blocks and distension. Blockade of the suprascapular nerve using various techniques and pharmaceutical agents has been advocated to reduce pain and aid functional recovery.⁵⁶⁻⁵⁹ Several studies describe the use of

physiotherapy⁶⁰⁻⁶⁵ and home exercises^{31,55,66} as successful methods of treatment. Intra-articular distension with or without steroid has also been suggested.⁶⁷⁻⁷³ Jacobs et al⁶⁷ found no difference in outcome between three groups in which either distension with local anaesthetic alone or steroid alone or distension and steroid were given. The follow-up was only for four months and therefore a comparison of treatment with the natural history is difficult.

Interventional (non-surgical) management. Table II^{16,74-84} summarises the studies in which frozen shoulder was treated by either physiotherapy techniques under analgesia or by MUA with or without other methods of treatment. All reported satisfactory results in most patients. They did not establish, however, whether any of these techniques changed the natural outcome of the disease. Meta-analysis is impossible because of the variable designs of study and treatment protocols.

Surgical management. Surgical intervention, either open or arthroscopic, aims to release the contracted tissue to gain movement and relieve pain. Table III^{46,85-96} summarises the studies in the recent literature reporting the surgical management of frozen shoulder. Ozaki et al⁴⁶ in 1989, in the first of two articles, reported the results of an open procedure for recalcitrant frozen shoulder. Open release of the coracohumeral ligament and rotator interval was carried out in 17 patients who were followed for a mean of 6.8 years. All had had failed conservative measures for a mean of 10.8

Table III. Summary of results for the surgical release of frozen shoulder

Author/s	Number of patients	Mean age (yrs)	Male:female ratio	Mean time of preop symptoms	Surgical treatment	Mean follow-up	Results
Ozaki et al ⁴⁶	17	53.5	10:7	10.5 mths	Open release and MUA	6.8 yrs	94% gained full ROM and pain relief
Omari and Bunker ⁸⁵	25	52.6	13:12	Not stated	Open release and MUA	19.5 mths	Increase in American Shoulder and Elbow Surgeon Score from 18.74 to 71.1
Segmuller et al ⁸⁶	24	50	14:10	Not stated	Arthroscopic release and full abduction	13.5 mths	88% satisfied, 76% normal function
Ogilvie-Harris et al ⁸⁷	38	32-72	14:24	Min 12 mths	20 MUA/20 arthroscopic release	2-5 yrs	ROM similar but release provided better function and pain relief
Warner et al ⁸⁸	23	48	11:12	12 mths	Arthroscopic release and MUA	39 mths	Mean Constant score increase by 48 points
Beaufils et al ⁸⁹	25	48	6:19	13 mths	Arthroscopic release	21 mths	69% very satisfied or satisfied Helps ROM during recovery
Pearsall et al ⁹⁰	46	49	22:24	12 mths	Arthroscopic release and steroid course	22 mths	83% normal or only mild symptoms
Watson et al ⁹¹	73	52	42:31	19.7 mths	Arthroscopic release	12 mths	Pain reduced by 2.2 wks ROM 10% that of other shoulder by 5.5 wks
Gerber et al ⁹²	45	50.8	37:8	8 mths	Arthroscopic release and MUA	26 mths	Mean Constant score increase from 41 to 75 points
Jerosch ⁹³	28	49	13:15	24 mths	Arthroscopic release	22 mths	Mean Constant score increase by 41 points
Bennett ⁹⁴	31	60	12:19	Min 6 wks	Arthroscopic release	18 mths (min)	Mean Constant score increase from 37 to 78 points
Nicholson ⁹⁵	68	50	27:41	Not stated	Arthroscopic release	3 yrs	Increase in ASES from 35.5 to 93 points
Massoud et al ⁹⁶	43	48	27:16	14.3 mths	MUA $\pm$ arthroscopic release	35 mths	Mean Constant score increase from 20.3 to 63.7 points

months. The results showed that 94% of patients had relief from pain and complete range of movement and 100% had normal strength. This number represented only a small fraction of the total number of patients with frozen shoulder who were reviewed (4.7%). They had all had an MUA as part of the procedure. A further study in 1996⁹⁷ had a larger number of patients (43) but a reduced mean follow-up for five years and produced similar results. Omari and Bunker⁸⁵ used the same surgical approach on 25 patients and reported good to excellent outcomes in 20 and fair in three. The two failures were associated with severe diabetes and Dupuytren's disease. Several authors have documented arthroscopic treatment for patients who have had failed conservative measures. Segmuller et al⁸⁶ described release of the inferior and middle glenohumeral ligaments with a follow-up of 13.5 months in 24 patients (26 shoulders); 88% were satisfied and 76% had normal function. These patients were put into full abduction during the procedure and steroid was placed into the joint and subacromial space at the end. Ogilvie-Harris et al⁸⁷ attempted to compare MUA with arthroscopic release in a prospective cohort of 40 patients. The release included removal of synovium from the rotator interval, release of the anterior glenohumeral ligament and the intra-articular portion of the subscapularis tendon, and finally, division of the anterior half of the inferior capsule.

Their results after a follow-up of between two and five years showed a similar range of movement, but the release had a better outcome in terms of pain and function. The overall outcome was excellent in 15 of 20 patients in the arthroscopic group but in only seven of 18 in the MUA group.

Warner et al⁸⁸ in 1996 studied 23 patients from an original series of 81 with frozen shoulder. All had an antero-inferior release combined with an MUA; six also had subacromial decompression. They then had inpatient physiotherapy for 48 hours under interscalene local anaesthetic blockade. The mean improvement in the Constant score was 48 points (13 to 77) with a significant improvement in the range of movement. Beaufils et al⁸⁹ in a French multicentre study, reviewed 26 patients after arthroscopic release of the capsule at the glenoid rim at a mean follow-up of 21 months. Although 69% were either very satisfied or satisfied, they concluded that there was no reduction in the time to recovery. They felt, however, that an increase in the range of movement during the recovery period was beneficial.

Pearsall et al⁹⁰ performed arthroscopic release of the antero-inferior capsule, the intra-articular portion of the tendon of subscapularis, the superior and middle glenohumeral ligaments and the coracohumeral ligament in patients who had had failed conservative treatment. A telephone survey of 35 patients at a mean of 22 months after

surgery reported that 83% had normal or only mildly symptomatic shoulders. These patients also had a reducing 21-day course of oral prednisolone. Watson et al⁹¹ reviewed 73 patients for up to one year after arthroscopic selective capsulotomy. They reported that pain took a mean of 2.24 weeks to decrease and that the range of movement improved to within 10% of the other side by 5.5 weeks. However, 37% required a further injection of steroid and 11% had a recurrence of pain during the follow-up period.

Gerber et al⁹² reviewed 45 patients after an arthroscopic 360° and rotator interval release with a mean follow-up of 26 months. In addition, all had an MUA. Nine had a primary frozen shoulder, 21 a postoperative frozen shoulder and in 15 the condition followed an injury. The primary patients had a better outcome than the postoperative patients and the trauma patients had the least favourable results. The gains within these groups were not significant and the outcome was dependent on the initial disability. The view that different types of frozen shoulder have a different behaviour and outcome was supported by Bennett,⁹⁴ and more recently by Nicholson⁹⁵ in a report of 68 patients undergoing arthroscopic release.

Massoud et al⁹⁶ reviewed the management of a subgroup of diabetic patients and concluded that a satisfactory outcome was achieved in both insulin- and non-insulin-dependent patients. Arthroscopic release, however, was required more often than in other non-diabetic studies. They admitted the limitations of the study in terms of a control group, lack of randomisation and that the investigators had not been blinded to treatment.

The reports of surgery for frozen shoulder mainly consider the release of the anteroinferior capsular structures. Most include MUA, which may address the other directional restrictions. It is impossible to compare or even accumulate the results in these published series since they all differ in surgical technique, length of follow-up and in the outcome measures used. All describe the need for conservative treatment initially. The timing of surgery varies, ranging from six weeks to one year from the onset of symptoms. There are no data concerning the outcome of early surgical intervention.

The most prominent omission is the lack of a control group which might allow comparison with the underlying natural progression of recovery. The duration of the follow-up in most studies is within the time period when a satisfactory outcome would be expected from the available data on the natural history. The data presented do not reveal if any of the treatments change the stiffness/time 'curve' or pain/time 'curve' of the condition. There are no true randomised control trials available which compare surgery with a control group.

In summary, several series report good to excellent results with either open or arthroscopic surgical release in a small number of patients who have had failed conservative treatment. Specific protocols of management of the condition seem to vary and depend upon prevalence in the popu-

lation and the constraints of the waiting list. Surgery should be in the armamentarium of orthopaedic surgeons, but there is limited evidence to show that it will truly change the natural course of this disabling condition.

References

1. Duplay S. De la peri-arthritis scapulo-humerales et des raideurs de l'épaule qui en sont la conséquence. *Arch Gen Med* 1872;20:513-4.
2. Codman E. Rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa. In: *The shoulder*. Boston. Thomas Todd, 1934.
3. Neviaser J. Adhesive capsulitis of the shoulder: a study of the pathological findings in periarthritis of the shoulder. *J Bone Joint Surg* 1945;27:211-22.
4. Zuckerman J, Cuomo F. Frozen shoulder. In: Hawkins R, ed. *The shoulder: a balance of mobility and stability*. Rosemont, IL. AAOS, 193:253-67.
5. Galatz L, Neviaser R. The frozen shoulder. In: Wulker N, Mansat M, Fu F, eds. *Shoulder surgery: an illustrated textbook*. London: M Dunitz, 2001:317-29.
6. Hannafin J, Chiaia T. Adhesive capsulitis. *Clin Orthop* 2000;372:95-109.
7. Neviaser R, Neviaser T. The frozen shoulder: diagnosis and management. *Clin Orthop* 1987;223:59-64.
8. Cameron R, McMillan J, Kelly I. Recurrence of a 'primary frozen shoulder': a case report. *J Shoulder Elbow Surg* 2000;9:65-7.
9. Reeves B. The natural history of the frozen shoulder syndrome. *Scand J Rheumatol* 1975;4:193-6.
10. Bulgen D, Binder A, Hazleman B, Park J. Immunological studies in frozen shoulder. *J Rheumatol* 1982;9:893-8.
11. Stam H. Frozen shoulder: a review of current concepts. *Physiotherapy* 1994;80:9.
12. Arkkila P, Kantola I, Viikari J, Ronnema T. Shoulder capsulitis in type I and II diabetic patients: association with diabetic complications and related diseases. *Ann Rheum Dis* 1996;55:907-14.
13. Choy E, Corkill M, Gibson T, Hicks B. Isolated ACTH deficiency presenting with bilateral frozen shoulder. *Br J Rheum* 1991;30:226-7.
14. Wohlgethan J. Frozen shoulder in hyperthyroidism. *Arthritis Rheum* 1987;30:936-9.
15. Bowman C, Jeffcoate WJ, Patrick M, Doherty M. Bilateral adhesive capsulitis, oligoarthritis and proximal myopathy as presentation of hypothyroidism. *Br J Rheum* 1988;27:62-4.
16. Andersen N, Sojbjerg J, Johannsen H, Sneppen O. Frozen shoulder: arthroscopy and manipulation under general anesthesia and early passive motion. *J Shoulder Elbow Surg* 1998;7:218-22.
17. Okamura K, Ozaki J. Bone mineral density of the shoulder joint in frozen shoulder. *Arch Orthop Trauma Surg* 1999;119:363-7.
18. Lundberg B, Nilsson B. Osteopenia in the frozen shoulder. *Clin Orthop* 1968;60:187-91.
19. Tuten H, Young D, Douguilh W, et al. Adhesive capsulitis of the shoulder in male cardiac surgery patients. *Orthopaedics* 2000;23:693-6.
20. Pineda C, Arana B, Martinez-Lavin M, Dabague J. Frozen shoulder triggered by cardiac catheterization via the brachial artery. *Am J Med* 1994;96:90-1.
21. Bruckner F, Nye J. A prospective study of adhesive capsulitis of the shoulder ('frozen shoulder') in a high risk population. *Q J Med* 1981;198:191-204.
22. Patten C, Hillel A. The 11th nerve syndrome. *Arch Otolaryngol Head Neck Surg* 1992;119:215-20.
23. Smith S, Devaraj V, Bunker T. The association between frozen shoulder and Dupuytren's disease. *J Shoulder Elbow Surg* 2001;10:149-51.
24. Riley D, Lang A, Blair R, Birnbaum A, Reid B. Frozen shoulder and other shoulder disturbances in Parkinson's disease. *J Neurol Neurosurg Psychiatr* 1989;52:63-6.
25. Boyle-Walker K, Gabard GL, Bietsch E, Masek-Van Arsdale DM, Robinson DL. A profile of patients with adhesive capsulitis. *J Hand Ther* 1997;10:222-8.
26. Wadsworth C. Frozen shoulder. *Phys Ther* 1986;66:1878-83.
27. Jayson M. Frozen shoulder: adhesive capsulitis. *Br Med J (Clin Res Ed)* 1981;283:1005-6.

28. Bunker T, Esler C. Frozen shoulder and lipids. *J Bone Joint Surg [Br]* 1995;77-B:684-6.
29. Hutchinson J, Tierney G, Parsons S, Davis T. Dupuytren's disease and frozen shoulder induced by treatment with a matrix metalloproteinase inhibitor. *J Bone Joint Surg [Br]* 1998;80-B:907-8.
30. Grey R. The natural history of idiopathic frozen shoulder. *J Bone Joint Surg [Am]* 1978;60-A:564.
31. Miller M, Wirth M, Rockwood C. Thawing the frozen shoulder: the 'patient' patient. *Orthopaedics* 1996;19:849-63.
32. Bulgen D, Binder A, Hazleman B, Dutton J, Roberts S. Frozen shoulder: prospective clinical study with an evaluation of three treatment regimens. *Ann Rheum Dis* 1984;43:353-60.
33. Binder A, Bulgen D, Hazleman B, Roberts S. Frozen shoulder: a long-term prospective study. *Ann Rheum Dis* 1984;43:361-4.
34. Shaffer B, Tibone J, Kerlan R. Frozen shoulder. *J Bone Joint Surg [Am]* 1992;74-A:738-46.
35. Jeracitano D, Cooper R, Lyon L, Jayson M. Abnormal temperature control suggesting sympathetic dysfunction in the shoulder skin of patients with frozen shoulder. *Br J Rheum* 1992;31:539-42.
36. Muller L, Muller L, Happ J, Kerschbaumer F. Frozen shoulder: a sympathetic dystrophy? *Arch Orthop Trauma Surg* 2000;120:84-7.
37. Wiffen F. What role does the sympathetic nervous system play in the development of ongoing pain of adhesive capsulitis? *J Manual Manipulative Therapy* 2002;10:17-23.
38. Muller L, Rittmeister M, John J, Happ J, Kerschbaumer F. Frozen shoulder: an algoneurodystrophic process? *Acta Orthop Belg* 2002;68(Suppl):79-85.
39. Mani R, Cooper C, Kidd B, Cole J, Cawley M. Use of laser Doppler flowmetry and transcutaneous oxygen tension electrodes to assess local autonomic dysfunction in patients with frozen shoulder. *J R Soc Med* 1989;82:536-8.
40. Brandser E, Renfrew D, Schenck R. Adhesive capsulitis of the wrist. *Can Assoc Radiol J* 1995;46:137-8.
41. Griffiths H, Utz R, Burke J, Bonfiglio T. Adhesive capsulitis of the hip and ankle. *AJR Am J Roentgenol* 1985;144:101-3.
42. McGrory B, Endrizzi D. Adhesive capsulitis of the hip after bilateral adhesive capsulitis of the shoulder. *Am J Orthop* 2000;29:457-60.
43. Gusman D, Dockery G. Adhesive lesions of the talocrural joint. *Clin Podiatr Med Surg* 1994;11:385-94.
44. Moppes FV, Vanden Hoogenband C, Greep J. Adhesive capsulitis of the ankle (frozen ankle). *Arch Orthop Trauma Surg* 1979;94:313-5.
45. Modesto C, Crespo E, Villas C, Aquerreta D. Adhesive capsulitis: is it possible in childhood? *Scand J Rheumatol* 1995;24:255-6.
46. Ozaki J, Nakagawa Y, Sakurai G, Tamai S. Recalcitrant chronic adhesive capsulitis of the shoulder. *J Bone Joint Surg [Am]* 1989;71-A:1511-5.
47. Neer CS 2nd, Satterlee C, Dalsey R, Flatow E. The anatomy and potential effects of contracture of the coracohumeral ligament. *Clin Orthop* 1992;280:182-5.
48. Rodeo S, Hannafin J, Tom J, Warren R, Wickieicz T. Immunolocalization of cytokines and their receptors in adhesive capsulitis of the shoulder. *J Orthop Res* 1997;15:427-36.
49. Bunker T, Anthony P. The pathology of frozen shoulder. *J Bone Joint Surg [Br]* 1995;77-B:677-83.
50. Lundberg B. Glycoaminoglycans of the normal and frozen shoulder-joint capsule. *Clin Orthop* 1970;69:279-84.
51. Bunker T, Reilly J, Baird K, Hamblen D. Expression of growth factors, cytokines and matrix metalloproteinases in frozen shoulder. *J Bone Joint Surg [Br]* 2000;82-B:768-73.
52. Bulgen D, Hazleman B, Voak D. HLA-B27 and frozen shoulder. *Lancet* 1976;968:1042-4.
53. Noy S, Dekel S, Orgad S, et al. HLA-B27 and frozen shoulder. *Tissue Antigens* 1981;17:251.
54. Signalet J, Sany J, Caillens J, Lapinski H. Lack of association between HLA-B27 and frozen shoulder. *Tissue Antigens* 1981;18:364.
55. Griggs S, Ahn A, Green A. Idiopathic adhesive capsulitis: a prospective functional outcome study of nonoperative treatment. *J Bone Joint Surg [Am]* 2000;82-A:1398-407.
56. Dahan T, Fortin L, Pelletier M, et al. Double blind randomized clinical trial examining the efficacy of bupivacaine suprascapular nerve blocks in frozen shoulder. *J Rheumatol* 2000;27:1464-9.
57. Jones D, Chattopadhyay C. Suprascapular nerve block for the treatment of frozen shoulder in primary care: a randomised trial. *Br J Gen Pract* 1999;49:39-41.
58. Karatas G, Meray J. Suprascapular nerve block for pain relief in adhesive capsulitis: comparison of two different techniques. *Arch Phys Med Rehabil* 2002;83:593-7.
59. Wassef M. Suprascapular nerve block: a new approach for the management of frozen shoulder. *Anaesthesia* 1992;47:120-4.
60. Carter B. A pilot study to evaluate the effectiveness of Bowen technique in the management of clients with frozen shoulder. *Complement Ther Med* 2001;9:208-15.
61. Polkinghorn B. Chiropractic treatment of frozen shoulder syndrome (adhesive capsulitis) utilizing mechanical force, manually assisted short lever adjusting procedures. *J Manipulative Physiol Ther* 1995;18:105-15.
62. Waldburger M, Meier J, Gobelet C. The frozen shoulder: diagnosis and treatment. Prospective study of 50 cases of adhesive capsulitis. *Clin Rheum* 1992;11:364-8.
63. Nicholson G. The effects of passive joint mobilization on pain and hypomobility associated with adhesive capsulitis of the shoulder. *J Orthop Sports Phys Therapy* 1985;6:238-46.
64. Vermeulen H, Obermann W, Burger B, et al. End-range mobilization techniques in adhesive capsulitis of the shoulder joint: a multiple-subject case report. *Phys Therapy* 2000;80:1204-13.
65. Hamer J, Kirk J. Physiotherapy and the frozen shoulder: a comparative trial of ice and ultrasonic therapy. *N Z Med J* 1976;83:191-2.
66. O'Kane J, Jackins S, Sidles JZ, Smith K, Matsen F. Simple home program for frozen shoulder to improve patients' assessment of shoulder function and health status. *J Am Board Fam Pract* 1999;12:270-7.
67. Jacobs L, Barton M, Wallace W, et al. Intra-articular distension and steroids in the management of capsulitis of the shoulder. *BMJ* 1991;302:1498-501.
68. Fareed D, Gallivan W. Office management of frozen shoulder syndrome: treatment with hydraulic distension under local anaesthesia. *Clin Orthop* 1989;242:177-83.
69. Jong B, Dahmen R, Hogeweg J, Marti RK. Intra-articular triamcinolone acetonide injection in patients with capsulitis of the shoulder: a comparative study of two dose regimens. *Clin Rehab* 1998;12:211-5.
70. Halverson L, Maas R. Shoulder joint capsule distension (hydroplasty): a case series of patients with "frozen shoulders" treated in a primary care office. *J Fam Pract* 2002;51:61-3.
71. Gam A, Schydlowsky P, Rossel I, Remvig L, Jensen E. Treatment of 'frozen shoulder' with distension and glucocorticoid compared with glucocorticoid alone. *Scand J Rheumatol* 1998;27:425-30.
72. van Royen B, Pavlov PW. Treatment of frozen shoulder by distension and manipulation under local anaesthesia. *Int Orthop* 1996;20:207-10.
73. Hsu S, Chan K. Arthroscopic distension in the management of frozen shoulder. *Int Orthop* 1991;15:79-83.
74. Haines J, Hargadon E. Manipulation as the primary treatment of the frozen shoulder. *J R Coll Surg Edinb* 1982;27:271-5.
75. Hill J, Bogumill H. Manipulation in the treatment of frozen shoulder. *Orthopaedics* 1988;11:1255-60.
76. Weber M, Prim J, Bugglin R, Michel B, Gerber H. Long-term follow-up of patients with frozen shoulder after mobilization under anesthesia, with special reference to the rotator cuff. *Clin Rheumatol* 1995;14:686-91.
77. Roubal P, Dobritt D, Placzek J. Glenohumeral gliding manipulation following interscalene brachial plexus block in patients with adhesive capsulitis. *JOSPT* 1996;24:66-77.
78. Placzek J, Roubal P, Freeman D, et al. Long-term effectiveness of translational manipulation for adhesive capsulitis. *Clin Orthop* 1998;356:181-91.
79. Dodenhoff R, Levy O, Wilson A, Copeland S. Manipulation under anesthesia for primary frozen shoulder: effect on early recovery and return to activity. *J Shoulder Elbow Surg* 2000;9:23-6.
80. Kivimaki J, Pohjolainen T. Manipulation under anesthesia for frozen shoulder with and without steroid injection. *Arch Phys Med Rehabil* 2001;82:1188-90.
81. Sharma R, Bajekal R, Bhan S. Frozen shoulder syndrome. *Int Orthop* 1993;17:275-8.
82. Pollock R, Duralde X, Flatow E, Bigliani L. The use of arthroscopy in the treatment of resistant frozen shoulder. *Clin Orthop* 1994;304:30-6.
83. Melzer C, Wallny T, Wirth C, Hoffman S. Frozen shoulder: treatment and results. *Arch Orthop Trauma Surg* 1995;114:87-91.

84. **Ekelund A, Rydell N.** Combination treatment for adhesive capsulitis of the shoulder. *Clin Orthop* 1992;282:105-9.
85. **Omari A, Bunker T.** Open surgical release for frozen shoulder: surgical findings and results of the release. *J Shoulder Elbow Surg* 2001;10:353-7.
86. **Segmuller H, Taylor D, Hogan C, Saies A, Hayes M.** Arthroscopic treatment of adhesive capsulitis. *J Shoulder Elbow Surg* 1995;319:238-48.
87. **Ogilvie-Harris D, Biggs D, Fitsialos D, Mackay M.** The resistant frozen shoulder. *Clin Orthop* 1995;319:238-48.
88. **Warner J, Answorth A, Marks P, Wong P.** Frozen shoulder: diagnosis and management. *J Am Acad Orthop Surg* 1997;5:130-40.
89. **Beaufils P, Prevot T, Boyer N, et al.** Arthroscopic release of the glenohumeral joint in shoulder stiffness: a review of 26 cases. *Arthroscopy* 1999;15:49-55.
90. **Pearsall AW 4th, Osbahr D, Speer K.** An arthroscopic technique for treating patients with frozen shoulder. *Arthroscopy* 1999;15:2-11.
91. **Watson L, Dalziel R, Story I.** Frozen shoulder: a 12-month clinical outcome trial. *J Shoulder Elbow Surg* 2000;9:16-22.
92. **Gerber C, Espinosa N, Perren T.** Arthroscopic treatment of shoulder stiffness. *Clin Orthop* 2001;390:119-28.
93. **Jerosch J.** 360 arthroscopic capsular release in patients with adhesive capsulitis of the glenohumeral joint: indication, surgical technique, results. *Knee Surg Sports Traumatol Arthrosc* 2001;9:178-86.
94. **Bennett W.** Addressing glenohumeral stiffness while treating the painful and stiff shoulder arthroscopically. *Arthroscopy* 2000;16:142-50.
95. **Nicholson G.** Arthroscopic capsular release for stiff shoulders: effects of etiology on outcomes. ESSSE/SECEC. Budapest, Hungary, 2002:176.
96. **Massoud S, Pearse E, Levy O, Copeland S.** Operative management of the frozen shoulder in patients with diabetes. *J Shoulder Elbow Surg* 2002;11:609-13.
97. **Ozaki J.** Pathomechanics and operative management of chronic frozen shoulder. *Ann Chir Gynaecol* 1996;85:156-8.