Frozen shoulder: overview of clinical presentation and review of the current evidence base for management strategies

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Adhesive capsulitis of the shoulder (ACS) is a condition with significant clinical and economic implications. The etiology of adhesive capsulitis is not clearly understood and there remains lack of consensus in clinical management for this condition. It can occur as a primary idiopathic condition or secondary to medical conditions or trauma. The hallmarks of ACS are pain and stiffness, caused by formation of adhesive or scar tissue in the glenohumeral joint. Management strategies vary depending on stage of presentation, patient factors and clinician preferences, and can range from conservative options to surgical intervention. The aim of this review is to summarize the pathophysiology and clinical presentation of ACS and to discuss the evidence base for various management strategies employed today.

Lay abstract: Frozen shoulder (FS) is a relatively common condition characterized by pain and stiffness of the shoulder joint. The exact cause of primary FS is unknown and in some patients the condition can persist for several years. Treatment strategies vary depending on stage of presentation, patient factors and clinician preferences. This review gives a summary of the clinical presentation of FS and an overview of the current evidence for both surgical and conservative treatment options for the condition.

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Adhesive capsulitis of the shoulder (ACS) was first described by Duplay in 1872 as ‘periarthritis’ and subsequently by Codman, who coined the term ‘frozen shoulder’ in 1934. ACS is characterized by varying degrees of pain and restricted movements of the glenohumeral joint. It occurs in approximately 2–5% of the population with a peak incidence between 40 and 70 years of age. It is more common in females and bilateral in 20–30% of cases. The condition is usually self-limiting; however, in some patients, symptoms can last for several years or may never fully resolve. Treatment for ACS remains a challenge today, placing a significant burden on healthcare systems as well as the wider economy, with patients unable to work for prolonged periods of time. This review article aims to give a brief overview of the pathophysiology and clinical presentation of ACS and to summarize the evidence base for conservative and surgical management of the condition.

Pathophysiology & clinical presentation

Adhesive capsulitis can be either primary or secondary; secondary causes of ACS include trauma, previous shoulder surgery, prolonged immobilization, diabetes, thyroid disease, Dupuytren disease and other autoimmune disorders. Primary idiopathic frozen shoulder occurs in patients presenting with painful, restricted shoulder movements where no underlying cause is found. The pathophysiology of primary adhesive capsulitis is still not fully understood, but histological studies have shown that frozen shoulder is characterized by a thickened, tight capsule, with chronic inflammatory cells and fibroblasts found in the joint capsule. Furthermore, fibroblasts in frozen shoulder have an activated phenotype associated with cytokine dysregulation, suggesting an autoimmune etiology.
Clinically, four stages of adhesive capsulitis have been described as a useful method of monitoring and assessing symptomatology (14) [Table 1]. The condition starts with a painful phase, characterized by pain and progressive restriction of movement. This phase is characterized by hypertrophic synovitis with hypervascularity, but a normal appearance of the capsular tissue (15). This is followed by a ‘freezing’ stage where symptoms gradually worsen over 9 months; histologically, there is perivascular synovitis and collagen deposition. Over the subsequent 1–4 months, the ‘frozen’ phase occurs, characterized by stiffness as a predominating symptom. The ‘thawing’ phase, in which symptoms resolve, has the greatest variability in duration and can last for up to 2 years. The latter two stages involve the formation of dense collagenous tissue in the capsule, associated with scar formation (15).

There is significant variation in clinical practice and the disease course may not follow such a stepwise progression. The diagnosis is usually made clinically, with pain and stiffness as the hallmark of the condition. The onset of pain is often gradual over a period of months, with night pain being a common feature. The pain may be poorly localized and described as a deep ache, or sometimes presents as a pain referred to the deltoid origin, radiating to the biceps area. Examination findings are often nonspecific without any point tenderness and with normal rotator cuff strength. However, both passive and active range of motion (ROM) are globally reduced; this is best assessed through passive external rotation with the arm by the side. The results of laboratory tests are usually normal but may be useful in identifying underlying conditions, such as diabetes or thyroid disease. Plain radiographs of the shoulder are also usually normal but can help diagnose or exclude other conditions, such as calcific tendinopathy of the rotator cuff, glenohumeral arthritis, acromioclavicular arthritis or even a shoulder dislocation. In calcific tendinopathy, disuse osteopenia may be demonstrated on the plain radiographs. Imaging modalities such as arthrography, technetium bone scans (16) and magnetic resonance imaging (17) are not routinely indicated or helpful in evaluation of adhesive capsulitis but can be used to exclude other shoulder pathology (18).

Management
The goal of treatment in ACS is to restore function and manage symptoms. The choice of treatment can vary with patient factors, stage at presentation, clinician preferences and local policies or funding. Nonsurgical or conservative management is the preferred choice of treatment, with most patients usually improving in 6–18 months (19). Conservative treatment options include analgesics, oral steroids, physical therapies, hydrodilatation, suprascapular nerve block (SNB) and intra-articular steroid or sodium hyaluronate injections. Surgical treatment is offered to patients with persistent symptoms despite conservative management; strategies include manipulation under anesthesia (MUA), arthroscopic release and open release. There remains no consensus or high-level evidence to definitively support one treatment modality over another.

Nonsurgical treatment
Physical therapy
Physical therapy has traditionally been the initial treatment modality in ACS and it is often utilized alongside other adjuncts, including steroid injections, transcutaneous electrical nerve stimulation, analgesics and warm or cold pads (20,21). There remains variation of physical therapy regimen in both clinical practice and in the literature; however, the principles revolve around a supervised stretching and strength maintenance program (22,23). In the early freezing stage, gentle stretching exercises of short duration are recommended, including pendulum exercises and passive external supine forward elevation (24). Strengthening exercises such as isometric shoulder external rotation and posterior capsular stretching can be introduced in the frozen stage (24). In the thawing stages, both strengthening and stretching exercises can be combined and increased in frequency, or combined with
Maitland Grade III–IV mobilization, to improve ROM. Griggs et al., in a prospective nonrandomized study of 75 patients, showed that a supervised stretching program resulted in a satisfactory outcome in 90% of patients at 22 months [25]. Vermeulen et al. [26] showed that high-grade mobilization (working through the pain barrier) was marginally better than low-grade mobilization (working within pain limits).

Despite the clinically prevalent use of physical therapy in ACS, there remains a lack of high-level evidence to support physical therapy over observation or medical therapy alone [18,27]. Randomized controlled trials (RCTs) by Bulgen et al. [28] and later by Carette et al. [29] showed no significant difference between patients who had physical therapy and those receiving no treatment. Further research is required to determine the role for physical therapy and adjuncts to treatment in ACS management.

**Pharmacological treatments**

Paracetamol and NSAIDs are often used as first-line treatments for pain in adhesive capsulitis. Analgesics may be more effective when combined with physical therapy [20] and although NSAIDs have been shown in some studies to provide significant improvement of symptoms compared with placebo [30], there is no high-level evidence to support this. Studies comparing different NSAIDs including naproxen and indomethicin have shown no significant differences in their effect [31,32].

Oral steroids have also been shown to have benefit in ACS; Buchbinder et al. [33] showed in a double-blind, placebo-controlled RCT that patients taking 30 mg oral prednisolone daily as a 3-week course had greater improvement in disability, range of active motion and overall pain compared with placebo groups (p = 0.001). However, there was no significant difference between the groups beyond 6 weeks; the authors recommended prednisolone for its short-term benefits. Similar findings were reported by Binder et al. [34], who showed in a study of 40 patients that night pain significantly improved in patients receiving oral prednisolone over the short term, but that there were no differences between groups at 8 months. There may be a role for oral steroids in ACS in providing short-term pain relief and ROM improvement; however, clinicians should exercise caution with the long-term use of steroids due to the high side effects profile and limited evidence in the literature to support their use in ACS for a prolonged period.

**Intra-articular steroid injections**

Intra-articular steroid injections are routinely used in the management of ACS and have been shown to provide better short-term pain relief and improved movement compared with oral steroids [35,36]. A recent meta-analysis with 225 patients showed that intra-articular steroid injections provided short-term analgesia (reduced pain score up to 8 weeks) and improved passive ROM in both short and long term (up to 24 weeks), compared with control groups receiving placebo [37]. Furthermore, a systematic review identified three high-quality RCTs showing a significant analgesic benefit of intra-articular injections, given between 6 weeks and 4 months, over placebo or physiotherapy alone [38]. Shah et al. reported that multiple injections are efficacious without causing significant complications [39]. Ultrasound-guided injections may be preferred because injections without radiological guidance have a high incidence of not entering the glenohumeral joint [40,41]. However, recent evidence also suggests there may be no significant difference in outcomes between subacromial and glenohumeral injection [42,43].

There is substantial high-level evidence in the literature comparing steroid injections with physiotherapy. Koh et al., in a systematic review of RCTs, report corticosteroid injections as superior to placebo and physiotherapy in the short term (12 weeks) [43]. Furthermore, a meta-analysis of nine RCTs with 453 patients found steroid injections equally as effective as physiotherapy; the authors recommend single steroid injection as the first line treatment in ACS [44]. However, several other RCTs have shown that steroid injections used as adjuncts to physiotherapy provide greater improvement in symptoms when compared with physical therapy alone [29,45,46].

**Intra-articular sodium hyaluronate injections**

Sodium hyaluronate can be used as an alternative to steroid injections [47] or indeed combined with steroids for the treatment of adhesive capsulitis [48]. A systematic review of seven studies with 140 ACS patients treated with hyaluronate injections showed hyaluronate to be better than placebo and as effective as corticosteroid injections, with the added benefit of fewer side effects [49]. In addition, it has been suggested that sodium hyaluronate may have a chondroprotective effect and improve the properties of synovial fluid [50]. A randomized study of 30 patients found tramadol with hyaluronate to be more effective than hyaluronate injections alone [51]. However, there
remains controversy in the literature, with Lee et al. showing in their review of four RCTs including 273 patients that intra-articular hyaluronate was not superior to corticosteroid injection or physical therapy [52].

**Hydrodilatation**

Intra-articular distension of the shoulder joint is an alternative method of treatment which has been shown to be of benefit but predominantly in the short term and has not been shown to have any significant benefit in the long term over other treatment modalities. The technique involves dilation of the capsule with either saline or steroid and local anesthetic in an attempt to stretch the capsule and break down any adhesions [53]. Quraishi et al. [54], in a randomized trial of 36 patients, compared hydrodilatation with manipulation under anesthesia and demonstrated improved functional scores over a six-month period (p = 0.02) in the hydrodilatation group. There was improvement but not statistical significance in ROM at 6 months in both groups.

Three RCTs have compared hydrodilatation with intra-articular steroid injection. Gam et al. [55] reported a significant improvement in ROM in the hydrodilatation group but pain and functional scores were comparable; ROM is not a validated outcome for ACS and the findings from this study should be interpreted with caution. Similarly, Tveita et al. [56] and Corbeil et al. [57] found no difference in outcomes of pain and ROM. In addition, one study by Khan et al. [58] compared hydrodilatation with physical therapy; ROM for abduction and external rotation was significantly improved at 8 weeks with hydrodilatation and physiotherapy compared with physiotherapy alone. However, once again there was no significant improvement demonstrated in pain score. The studies described here were limited by sample size and randomization, and the heterogeneity of study design makes it difficult to draw confident conclusions [55–58]. There is insufficient evidence in the literature to suggest hydrodilatation as superior to other treatment modalities in ACS.

**Suprascapular nerve block**

The suprascapular nerve arises from the superior trunk of the brachial plexus (C5, C6) and supplies the muscles of the rotator cuff, namely the supraspinatus and the infraspinatus. SNB involves local anesthetic infiltration through a needle inserted behind the lateral end of the clavicle at the insertion of the trapezius [59]. The effectiveness of SNB may be improved using electromyographic or ultrasound guidance [60–62]. In a double-blind, placebo-controlled RCT of 34 patients, Dahan et al. [63] demonstrated a significantly greater improvement in pain (p = 0.03) but no difference in function (p = 0.24) after SNB with bupivacaine compared with placebo at 1 month. Similarly, Jones et al. performed a prospective RCT and showed that SNB may also provide quicker and more complete resolution of symptoms compared with intra-articular steroid injections [62]. Mortada et al. showed in their trial of 96 patients that a course of nine injections gave a better outcome than a single injection [64]. The literature suggests that SNB could be an effective short-term strategy in ACS, although larger multicenter trials would be useful in further defining its role.

**Surgical treatment**

**Manipulation under anesthesia**

Surgical treatments are usually reserved for patients who have persistent symptoms despite nonoperative treatment for between 2 and 6 months [65–67]. Manipulation of the shoulder is a technique in which the patient is anesthetized and the joint is manipulated to break down thickened and stiff capsular tissue. MUA has been shown to have good results in both the short and the long term, particularly when followed with a program of physical therapy [68,69]. MUA may also be combined with interscalene blocks, which have been shown to provide a sustained improvement in both function and movement at 12 months [70]. Furthermore, Farrell et al. demonstrated long-term improvements up to 15 years after MUA [71].

There are, however, significant complications to consider with MUA; these include humeral fractures, glenoid fractures, glenohumeral joint dislocation, rotator cuff tears (especially subscapularis), biceps tendon injuries and labral tears. Care needs to be taken when performing the procedure to avoid these complications while performing an effective manipulation to break down the inferior capsule. Manipulation techniques vary in clinical practice and in the literature, as described by Kraal et al. in their review [72].

**Arthroscopic release**

Arthroscopic release is often the preferred method of surgical treatment in refractory cases of adhesive capsulitis. It was first described in 1979 by Conti [73] and helps avoid the potential but significant complications of MUA.
Arthroscopic release has been shown to have good short- and long-term outcomes in terms of both pain and function [74,75]. Arthroscopic release is also effective in patients with insulin-dependent diabetes mellitus, although the outcomes are better in nondiabetic patients [76]. Similarly, patients with idiopathic and posttraumatic adhesive capsulitis have better outcomes than patients with postoperative adhesive capsulitis [77].

There are several other advantages to arthroscopic release, including controlled release of contracted capsule, synovectomy (if necessary), direct visualization of the joint and identification of other shoulder pathology. In addition, postoperative physical therapy can be started early because patients often have minimal pain. There are, however, some potential complications, including pain and recurrent stiffness, anterior dislocation of the shoulder and axillary nerve injury.

Although arthroscopic release has been shown to have good outcomes, there is still some controversy as to the surgical technique, particularly relating to the extent of the surgical release. Ogilvie-Harris et al. reported good pain relief and functional improvement after arthroscopic release of the intra-articular part of the subscapularis (IASS), superior glenohumeral ligament and the rotator interval [74]. Pearsall et al. reported that the IASS can be released during arthroscopic capsular release for frozen shoulder with minimal risk of secondary anterior instability [78]. However, the need to release the IASS is debatable and there is no definitive evidence to demonstrate that it confers significantly better outcomes. Snow et al. demonstrated no significant difference in improvement of ROM with both anterior and posterior capsular release compared with anterior release alone [79]. Conversely, Jerosch suggested that a 360-degree circumferential capsular release was a reliable method for restoring motion with minimum morbidity [80].

Kanbe et al. divided 267 ACS patients who underwent arthroscopic release into three groups, based on the severity of the adhesion between the coracohumeral ligament and the long head of biceps (LHB) tendon [81]. At 5 years post-surgery, all groups had significantly improved functional scores; however, patients with severe LHB and coracohumeral adhesion had significantly different outcomes from those with less severe adhesions (p < 0.0001) [81]. Notably, the authors also found diabetes mellitus to be a significant risk factor for severity of adhesion. This study highlights the importance of intraoperative release of LHB in arthroscopic release surgery for ACS.

Open release

Open release for adhesive capsulitis is an uncommon procedure because arthroscopic surgery carries significantly less postoperative morbidity. It may, however, be an option in patients who have had unsuccessful arthroscopic release; it has been shown to produce good outcomes in terms of both pain and ROM [82,83], although diabetic patients had poorer outcomes [82]. Omari et al. showed functional and symptomatic improvement after open arthroscopic release in 25 patients who had failed MUA [84]. Additional indications for open release include patients who have suffered strokes or head injuries and in posttraumatic or postsurgical adhesive capsulitis where there are significant adhesions and contractures preventing arthroscopic surgery [85].

Conclusion

ACS is a common condition that causes significant and prolonged morbidity for patients and carries wider economic implications. The management of adhesive capsulitis remains a challenge and there is a need for high-level, definitive evidence to suggest one form of treatment over another. As such, the treatment of this condition remains varied in clinical practice. There is moderate evidence for conservative approaches in the initial stages of ACS, including analgesics, oral steroids, intra-articular steroid or sodium hyaluronate injections, SNB and physiotherapy. Evidence in the literature for the efficacy of hydrodilatation therapy remains inconclusive. In cases resistant to conservative management strategies, MUA or arthroscopic capsular release are evidence-based treatment alternatives. There is limited evidence for open release, and it is also associated with greater post-operative morbidity compared with arthroscopic release. Surgical treatments should be complemented with an appropriate, supervised physical therapy regimen. Further understanding of the underlying pathology of ACS and large, randomized multicenter studies are required in order to define an evidence-based management strategy for the condition.

Future perspective

The last two decades have seen significant progress in our understanding of the pathophysiology behind ACS, which has complemented developments in current management strategies. However, there remains variation in clinical practice with no consensus in treatment for this condition. Nonoperative interventions remain first-line approaches in managing ACS and there is an urgent need for prospective RCTs comparing the efficacy of different
treatment strategies. Furthermore, as our understanding of the immunological etiology of ACS develops, there may be opportunities for immunomodulating or targeted therapies in the future.

### Executive summary

- Adhesive capsulitis of the shoulder (ACS) is a relatively common condition characterized by pain and stiffness of the shoulder joint.
- The pathophysiology of ACS is still not fully understood; however, histological studies have shown that the condition is characterized by a thickened, tight capsule, with chronic inflammatory cells and fibroblasts found in the joint capsule.
- Clinically, the presentation can be classified into four stages: painful, freezing, frozen and thawing.
- The goal of treatment is to restore patient function and manage symptoms, with a myriad of nonoperative and operative treatment strategies used in clinical practice.
- Physical therapy, often with adjuncts, is the preferred first-line treatment, although there remains a lack of high-level evidence in the literature to support this approach.
- Oral steroids have been shown to be effective in the short term, although their benefits after 6 weeks remain doubtful.
- Steroid injections have been shown in the literature to be as effective as, or even superior to, physiotherapy in the management of ACS.
- Sodium hyaluronate has been shown in one systematic review to be as effective as steroids and more effective than placebo; however, the evidence in the literature is controversial.
- There is a need for further research on the effectiveness of suprascapular nerve block and hydrodilatation, with some studies demonstrating promising results.
- Surgical treatment strategies of manipulation under anesthesia and arthroscopic release are effective in persistent cases of ACS, although there is variation in technique in both clinical practice and literature.

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Both authors contributed equally to the writing of this paper.

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### References

Papers of special note have been highlighted as: ● of interest; ●● of considerable interest

1. Duplay S. De la péri-arthrite scapulo-humérale et des raideurs de l’épaule qui en sont la conséquence. In: Archives Générales de Médecine, Novembre 1872 (Édition originale). Jean-Pierre Aubert (1872). www.abebooks.com/first-edition/p%C3%A9ri-arthrite-scapulo-hum% C3%A9rale-raideurs-%C3%A9paule-cons%C3%A9quence-Archives/22693949881/bd
2. Codman E. The Shoulder Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa. T. Todd Company printers, MA, USA (1934). https://archive.org/details/b29812161
3. Neviaser JS. Adhesive capsulitis of the shoulder: a study of the pathological findings in periarthritis of the shoulder. J. Bone Joint Surg. 27(2), 211–222 (2020).
4. Zuckerman JD, Rokito A. Frozen shoulder: a consensus definition. J. Shoulder Elbow Surg. 20(2), 322–325 (2011).
5. Bouaicha S, Wieser K, Kriechling P, Scholz-Odermatt SM. A large-scale assessment of the healthcare burden of adhesive capsulitis of the shoulder joint. Swiss Med. Wkly 150, w20188 (2020).
6. Lundberg J. The frozen shoulder. Clinical and radiological observations. The effect of manipulation under general anesthesia. Structure and glycosaminoglycan content of the joint capsule. Local bone metabolism. Acta Orthop. Scand. 119, 1–59 (1969).
7. Janda DH, Hawkins RJ. Shoulder manipulation in patients with adhesive capsulitis and diabetes mellitus: a clinical note. J. Shoulder Elbow Surg. 2(1), 36–38 (1993).
1. Bowman CA, Jeffcoat WJ, Patrick M, Doherty M. Bilateral adhesive capsulitis, oligoarthritis and proximal myopathy as presentation of hypothyroidism. *Br. J. Rheumatol.* 27(1), 62–64 (1988).

2. Bulgen D, Hazleman BL, Ward M, McCallum M. Immunological studies in frozen shoulder. *Ann. Rheum. Dis.* 37(2), 135–138 (1978).

3. Hand GCR, Athanasou NA, Matthews T, Carr AJ. The pathology of frozen shoulder. *J. Bone Joint Surg.* 89(7), 928–932 (2007).

4. Rodeo SA, Hannafin JA, Tom J, Warren RF, Wickiewicz TL. Immunolocalization of cytokines and their receptors in adhesive capsulitis of the shoulder. *J. Orthop. Res.* 15(3), 427–436 (1997).

5. Akbar M, McLean M, Garcia-Melchor E et al. Fibroblast activation and inflammation in frozen shoulder. *PLoS ONE* 14(4), e0215301 (2019).

6. Hannafin JA, Chiaia TA. Adhesive capsulitis: a treatment approach. *Clin. Orthop.* 372, 95–109 (2000).

7. Yuan X, Zhang Z, Li J. Pathophysiology of adhesive capsulitis of shoulder and the physiological effects of hyaluronan. *Eur. J. Inflamm.* 15(3), 239–243 (2017).

8. Bowman CA, Jeffcoate WJ, Patrick M, Doherty M. Bilateral adhesive capsulitis, oligoarthritis and proximal myopathy as presentation of hypothyroidism. *Br. J. Rheumatol.* 27(1), 62–64 (1988).

9. Smith SP, Devaraj VS, Bunker TD. The association between frozen shoulder and Dupuytren's disease. *J. Shoulder Elbow Surg.* 10(2), 149–151 (2001).

10. Bulgen D, Hazleman BL, Ward M, McCallum M. Immunological studies in frozen shoulder. *Ann. Rheum. Dis.* 37(2), 135–138 (1978).

11. Hand GCR, Athanasou NA, Matthews T, Carr AJ. The pathology of frozen shoulder. *J. Bone Joint Surg.* 89(7), 928–932 (2007).

12. Rodeo SA, Hannafin JA, Tom J, Warren RF, Wickiewicz TL. Immunolocalization of cytokines and their receptors in adhesive capsulitis of the shoulder. *J. Orthop. Res.* 15(3), 427–436 (1997).

13. Akbar M, McLean M, Garcia-Melchor E et al. Fibroblast activation and inflammation in frozen shoulder. *PLoS ONE* 14(4), e0215301 (2019).

14. Hannafin JA, Chiaia TA. Adhesive capsulitis: a treatment approach. *Clin. Orthop.* 372, 95–109 (2000).

15. Yuan X, Zhang Z, Li J. Pathophysiology of adhesive capsulitis of shoulder and the physiological effects of hyaluronan. *Eur. J. Inflamm.* 15(3), 239–243 (2017).

16. Binder Al, Bulgen D, Hazleman BL, Tudor J, Wraight P. Frozen shoulder: an arthrographic and radionuclear scan assessment. *Ann. Rheum. Dis.* 43(3), 365–369 (1984).

17. Mengiardi B, Pfirrmann CWA, Gerber C, Hodler J, Zanetti M. Frozen shoulder: MR arthrographic findings. *Radiology* 233(2), 486–492 (2004).

18. Manton GL, Schweitzer ME, Weishaupt D, Karasick D. Utility of MR arthrography in the diagnosis of adhesive capsulitis. *Skeletal Radiol.* 30(6), 326–330 (2001).

19. Georgiannos D, Markopoulos G, Devetzi E, Bisbinas I. Adhesive capsulitis of the shoulder. Is there consensus regarding the treatment? A comprehensive review. *Open Orthop.* J. 11(1), 65–76 (2017).

20. Leung MSF, Cheing GLY. Effects of deep and superficial heating in the management of frozen shoulder. *J. Rehabil. Med.* 40(2), 145–150 (2008).

21. Rizk TE, Christopher RP, Pinals RS, Higgins AC, Frix R. Adhesive capsulitis (frozen shoulder): a new approach to its management. *Arch. Phys. Med. Rehabil.* 64(1), 29–33 (1983).

22. Chan HBY, Pua PY, How CH. Physical therapy in the management of frozen shoulder. *Singapore Med. J.* 58(12), 685–689 (2017).

23. van der Zwaal P, van de Laar S. Management of the frozen shoulder. *Phys. Med. Rehabil.* 40(2), 145–150 (2000).

24. Chan HBY, Pua PY, How CH. Physical therapy in the management of frozen shoulder. *Singapore Med. J.* 58(12), 685–689 (2017).

25. Idiopathic adhesive capsulitis. A prospective functional outcome study of nonoperative treatment. *J. Bone Joint Surg.* 82(10), 1398–1407 (2000).

26. Highly cited prospective controlled trial for use of physical therapy in (adhesive capsulitis of the shoulder) ACS.

27. Van Meumen HM, Reizing PM, Obermann WR, le Cessie S, Vliet Vlieland TPM. Comparison of high-grade and low-grade mobilization techniques in the management of adhesive capsulitis of the shoulder: randomized controlled trial. *Phys. Ther.* 86(3), 355–368 (2006).

28. Cleland J, Durall CJ. Physical therapy for adhesive capsulitis: systematic review. *Physiotherapy* 88(8), 450–457 (2002).

29. Bulgen D, Hazleman BL, Ward M, McCallum M. Immunological studies in frozen shoulder. *Ann. Rheum. Dis.* 37(2), 135–138 (1978).

30. Carette S, Moffet H, Tardif J et al. Intraarticular corticosteroids, supervised physiotherapy, or a combination of the two in the treatment of adhesive capsulitis of the shoulder: a placebo-controlled trial. *Arthritis Rheum.* 48(3), 829–838 (2003).

31. van der Windt DAWM, van der Heijden GJMG, Scholten RJPM, Koes BW, Bouter LM. The efficacy of non-steroidal anti-inflammatory drugs (NSAIDs) for shoulder complaints. A systematic review. *Physiotherapy* 88(8), 450–457 (2002).

32. Van Meumen HM, Reizing PM, Obermann WR, le Cessie S, Vliet Vlieland TPM. Comparison of high-grade and low-grade mobilization techniques in the management of adhesive capsulitis of the shoulder: randomized controlled trial. *Phys. Ther.* 86(3), 355–368 (2006).

33. Cleland J, Durall CJ. Physical therapy for adhesive capsulitis: systematic review. *Physiotherapy* 88(8), 450–457 (2002).

34. Bulgen D, Hazleman BL, Ward M, McCallum M. Immunological studies in frozen shoulder. *Ann. Rheum. Dis.* 37(2), 135–138 (1978).

35. Widdel O, Anagnostakos K, Scherf C, Seil R, Kohn D, Pape D. Nonoperative management of adhesive capsulitis of the shoulder: oral cortisone application versus intra-articular cortisone injections. *J. Shoulder Elbow Surg.* 19(2), 172–179 (2010).

36. Wang W, Shi M, Zhou C et al. Effectiveness of corticosteroid injections in adhesive capsulitis of shoulder. *Medicine (Baltimore)* 96(28), e7529 (2017).
38. Favejee MM, Huistede BMA, Koes BW. Frozen shoulder: the effectiveness of conservative and surgical interventions – systematic review. Br. J. Sports Med. 45(1), 49–56 (2011).
39. Shah N, Lewis M. Shoulder adhesive capsulitis: systematic review of randomised trials using multiple corticosteroid injections. Br. J. Gen. Pract. 57(541), 662–667 (2007).
40. Lorbach O, Kieb M, Scherf C, Seil R, Kohn D, Pape D. Good results after fluoroscopically-guided intra-articular injections in the treatment of adhesive capsulitis of the shoulder. Knee Surg. Sports Traumatol. Arthrosc. 18(10), 1435–1441 (2010).
41. Eustace JA, Brophy DP, Gibney RP, Bresnihan B, FitzGerald O. Comparison of the accuracy of steroid placement with clinical outcome in patients with shoulder symptoms. Ann. Rheum. Dis. 56(1), 59–63 (1997).
42. Shang X, Zhang Z, Pan X, Li J, Li Q. Intra-articular versus subacromial corticosteroid injection for the treatment of adhesive capsulitis: a meta-analysis and systematic review. BioMed. Res. Int. 2019, 1274790 (2019).
43. Koh KH. Corticosteroid injection for adhesive capsulitis in primary care: a systematic review of randomised clinical trials. Singapore Med. J. 57(12), 646–657 (2016).

**High-level evidence comparing steroid injections with physical therapy in ACS management.**

44. Sun Y, Lu S, Zhang P, Wang Z, Chen J. Steroid injection versus physiotherapy for patients with adhesive capsulitis of the shoulder. Medicine (Baltimore) 95(20), e3469 (2016).

**High-level evidence comparing steroid injections with physical therapy in ACS management.**

45. Kraal T, Sierevelt I, van Deurzen D, van den Bekerom MPJ, Beimers L. Corticosteroid injection alone vs additional physiotherapy in ACS management.

46. Anjum R, Aggarwal J, Gautam R, Pathak S, Sharma A. Evaluating the outcome of different regimes in adhesive capsulitis: a prospective clinical study. Med. Prim. Pract. 29(3), 225–230 (2020).

47. Calis M, Demir H, Ulker S, Kirnap M, Duygulu F, Calis HT. Intraarticular sodium hyaluronate injection an alternative treatment in patients with adhesive capsulitis? Rheumatol. Int. 26(6), 536–540 (2006).

48. Rovetta G, Monteforte P. Intraarticular injection of sodium hyaluronate plus steroid versus steroid in adhesive capsulitis of the shoulder. Int. J. Tissue React. 20(4), 125–130 (1998).

49. Harris JD, Griesser MJ, Copelan A, Jones GL. Treatment of adhesive capsulitis with intra-articular hyaluronate: a systematic review. Int. J. Shoulder Surg. 5(2), 31–37 (2011).

50. Iwata H. Pharmacologic and clinical aspects of intraarticular injection of hyaluronate. Clin. Orthop. 289, 285–291 (1993).

51. Kim KH, Suh JW, Oh KY. The effect of intra-articular hyaluronate and tramadol injection on patients with adhesive capsulitis of the shoulder. J. Back Musculoskelet. Rehabil. 30(4), 913–920 (2017).

52. Lee LC, Lieu FK, Lee HL, Tung TH. Effectiveness of hyaluronic acid administration in treating adhesive capsulitis of the shoulder: a systematic review of randomized controlled trials. Biomed. Res. Int. 2015, 314120 (2015).

53. Rockwood and Matsen’s The Shoulder, 2 Volume Set 4th Edition.

54. Quraishi NA, Johnston P, Bayer J, Crowe M, Chakrabarti AJ. Thawing the frozen shoulder: a randomized trial comparing manipulation under anaesthesia with hydrodilatation. J. Bone Joint Surg. 89(9), 1197–1200 (2007).

55. Gam AN, Schydowsky P, Rosell I, Remvig L, Jensen EM. Treatment of ‘frozen shoulder’ with distension and glucocorticoid compared with glucocorticoid alone: a randomised controlled trial. Scand. J. Rheumatol. 27(6), 425–430 (1998).

56. Tveit˚a EK, Tariq R, Sesseng S, Juel NG, Bautz-Holter E. Hydrodilatation, corticosteroids and adhesive capsulitis: a randomized controlled trial. BMC Musculoskelet. Disord. 9, 53 (2008).

57. Corbeil V, Dussault RG, Leduc BE, Fleury J. [Adhesive capsulitis of the shoulder: a comparative study of arthroscopy with intra-articular corticotherapy and with or without capsular distension]. Can. Assoc. Radiol. J. 43(2), 127–130 (1992).

58. Khan AA, Mowla A, Shakkor MA, Rahman MR. Arthrographic distension of the shoulder joint in the management of frozen shoulder. Mymensingh Med. J. 14(1), 67–70 (2005).

59. Wassef MR. Suprascapular nerve block: a new approach for the management of frozen shoulder. Anaesthesia 47(2), 120–124 (1992).

60. Karata GK, Meray J. Suprascapular nerve block for pain relief in adhesive capsulitis: comparison of 2 different techniques. Arch. Phys. Med. Rehabil. 83(5), 593–597 (2002).

61. Berglum J, Bartholdy A, Hautopp H, Krogsgaard MR, Jensen K. Ultrasound-guided continuous suprascapular nerve block for adhesive capsulitis: one case and a short topical review. Acta Anaesthesiol. Scand. 55(2), 242–247 (2011).

62. Jones DS, Chatterpadhyay C. Suprascapular nerve block for the treatment of frozen shoulder in primary care: a randomized trial. Br. J. Gen. Pract. 49(438), 39–41 (1999).

63. Dahan TH, Fortin L, Pelletier M, Peit M, Vadeboncoeur R, Suissa S. Double blind randomized clinical trial examining the efficacy of bupivacaine suprascapular nerve blocks in frozen shoulder. J. Rheumatol. 27(6), 1464–1469 (2000).
Frozen shoulder: overview of clinical presentation & review of the current evidence base for management strategies

64. Mortada MA, Ezzeldin N, Abbas SF, Ammar HA, Salama NA. Multiple versus single ultrasound guided suprascapular nerve block in treatment of frozen shoulder in diabetic patients. *J. Back Musculoskelet. Rehabil.* 30(3), 537–542 (2017).

65. Cho CH, Bae KC, Kim DH. Treatment strategy for frozen shoulder. *Clin. Orthop. Surg.* 11(3), 249–257 (2019).

66. Kessel L, Bayley I, Young A. The upper limb: the frozen shoulder. *Br. J. Hosp. Med.* 25(4), 336–337 (1981).

67. Neviaser AS, Neviaser RJ. Adhesive capsulitis of the shoulder. *J. Am. Acad. Orthop. Surg.* 19(9), 536–542 (2011).

68. Ng CY, Amin AK, Narborough S, McMullan L, Cook R, Brenkel IJ. Manipulation under anaesthesia and early physiotherapy facilitate recovery of patients with frozen shoulder syndrome. *Scott. Med. J.* 54(1), 29–31 (2009).

69. Kivimäki J, Poujolainen T, Malmivaara A et al. Manipulation under anesthesia with home exercises versus home exercises alone in the treatment of frozen shoulder: a randomized, controlled trial with 125 patients. *J. Shoulder Elbow Surg.*, 16(6), 722–726 (2007).

70. Fox A, Board T, Sririvasan MS. Improvement in shoulder function following manipulation for adhesive capsulitis: how long does it last? *Orthopaed. Proc.* 88-B(Suppl. 1) (2018).

71. Farrell CM, Sperling JW, Cofield RH. Manipulation for frozen shoulder: long-term results. *J. Shoulder Elbow Surg.* 14(5), 480–484 (2005).

72. Kraal T, Beimers I, The B, Sierveelt I, van den Bekerom M, Eygendaal D. Manipulation under anaesthesia for frozen shoulders: outdated technique or well-established quick fix? *EFORT Open Res.* 4(3), 98–109 (2019).

73. Conti V. Arthroscopy in rehabilitation. *Orthop. Clin. North Am.* 10(3), 709–711 (1979).

74. Ogilvie-Harris DJ, Biggs DJ, Fitsialos DP, MacKay M. The resistant frozen shoulder. Manipulation versus arthroscopic release. *Clin. Orthop. Relat. Res.* (319), 238–248 (1995).

75. Ide J, Takagi K. Early and long-term results of arthroscopic treatment for shoulder stiffness. *J. Shoulder Elbow Surg.* 13(2), 174–179 (2004).

76. Çınar M, Akpmar S, Derincek A, Cirici E, Uysal M. Comparison of arthroscopic capsular release in diabetic and idiopathic frozen shoulder patients. *Arch. Orthop. Trauma Surg.* 130(3), 401–406 (2010).

77. Elhassan B, Ozbaydar M, Massimini D, Higgs L, Warner JJP. Arthroscopic capsular release for refractory shoulder stiffness: a critical analysis of effectiveness in specific etiologies. *J. Shoulder Elbow Surg.* 19(4), 580–587 (2010).

78. Pearsall AW IV, Holovacs TF, Speer KP. The intra-articular component of the subscapularis tendon: anatomic and histological correlation in reference to surgical release in patients with frozen-shoulder syndrome. *Arthroscopy* 16(3), 236–242 (2000).

79. Snow M, Boutros I, Funk L. Posterior arthroscopic capsular release in frozen shoulder. *Arthroscopy* 25(1), 19–23 (2009).

80. Jerosch J. 360° arthroscopic capsular release in patients with adhesive capsulitis of the glenohumeral joint - indication, surgical technique, results. *Knee Surg. Sports Traumatol. Arthrosc.* 9(3), 178–186 (2001).

81. Kanbe K. Clinical outcome of arthroscopic capsular release for frozen shoulder: essential technical points in 255 patients. *J. Orthop. Surg. Res.* 13(1), 56 (2018).

- **Long-term study looking at 5-year outcomes in patients undergoing arthroscopic capsular release.**

82. Omari A, Bunker TD. Open surgical release for frozen shoulder: surgical findings and results of the release. *J. Shoulder Elbow Surg.* 10(4), 353–357 (2001).

83. Ozaki J, Nakagawa Y, Sakurai G, Tami S. Recalcitrant chronic adhesive capsulitis of the shoulder. Role of contracture of the coracohumeral ligament and rotator interval in pathogenesis and treatment. *J. Bone Joint Surg. Am.* 71(10), 1511–1515 (1989).

84. Omari A, Bunker TD. Open surgical release for frozen shoulder: surgical findings and results of the release. *J. Shoulder Elbow Surg.* 10(4), 353–357 (2001).

85. Braun RM, West F, Mooney V, Nickel VL, Roper B, Caldwell C. Surgical treatment of the painful shoulder contracture in the stroke patient. *J. Bone Joint Surg. Am.* 53(7), 1307–1312 (1971).