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ORIGINAL PAPER

# Manipulation under anaesthetic for frozen shoulder using Codman's paradox: a safe and early return of function

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**Abstract**
*Purpose* Although previously frozen shoulder was thought to resolve by two to three years, recent studies demonstrated the symptoms can remain for much longer. Manipulation under anaesthetic (MUA) has been shown to be successful in relieving pain and restoring function. Yet, concerns have been raised regarding its safety and the risks of complications. We utilise Codman's paradox to manipulate the shoulder, avoiding rotational torque on the humerus. The aim of our study was to asses shoulder function in the early post MUA period.
*Methods* Two hundred twelve consecutive patients (224 shoulders) (mean age 52.4 years) underwent MUA using Codman's paradox for frozen shoulder as sole procedure between 2005 and 2013. All were evaluated clinically, preoperatively and postoperatively, at three weeks and three months, for Constant score (CS), pain, range of motion (ROM), patient satisfaction and subjective shoulder value (SSV).
*Results* At three weeks and three months, a significant improvement was found in CS from 30.7 to 66 and 70 respectively. Forward elevation improved from 91° to 154° and 160 °, abduction from 69° to 150° and 156 °, internal rotation from 12° to 62° and 66 °, and external rotation from 10° to 46° and 50 °. Pain score improved from 4.4/15 to 9.6/15 and 10.4/15, SSV improved from 1.5/10 to 6.5/10 and 6.7/10. ($p<0.001$).
*Conclusion* Use of Codman's paradox provides a safe and efficient way to perform MUA for frozen shoulder. It results in dramatic early improvement in ROM, functional outcomes and high satisfaction, as early as three weeks post-operatively.

**Keywords** Frozen · Shoulder · Manipulation · Anasthesia · Codman · Range of motion

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## Introduction

Frozen shoulder remains an enigma [1]. Although previously it was thought to resolve by two to three years, recent studies demonstrated that pain and limitation of movement can remain for much longer. [2, 3]. The long duration has major implications on patient function, satisfaction and overall quality of life.

Surgeons have used multiple techniques including NSAID treatment [4], oral steroids [5], intra-articular steroid injections [6], physical therapy [7], watchful neglect [8, 9], gentle stretching and patience [10], suprascapular nerve block [11], hydrodilatation [12–14], manipulation under anaesthesia [15–17] and arthroscopic capsular release [18].

It is difficult to quantify the economic burden of a two to three year's conservative treatment [19]; we estimate it to be of consequence. Of concern is the lengthy disability produced by frozen shoulder, and attempts need to be mad to shorten the time required for recovery. It has been shown that MUA is an effective therapy with early recovery of function [15]. However, the term "manipulation under anaesthesia" is general and entails many different techniques. Of major importance are the details of each technique.

Surgeons are concerned about the risks of shoulder manipulation. Those include humeral shaft fractures, shoulder dislocation, rotator cuff injury, post-manipulation pain, and traction injury to nerves about the shoulder [20, 21]. Quigley [22]

reported one fracture of the anatomic neck of the humerus of 44 shoulder manipulated. Hamdan [20] reported out of 110 shoulders manipulated, two crack fractures of the surgical neck of the humerus, and two other shoulders which required immediate reduction for glenohumeral dislocation. Magnussen [21] in a case report described a glenoid fracture. Othman [23] reported one shoulder subluxation during the procedure which was immediately reduced, with satisfactory outcome. Birch [24] treated three cases of brachial plexus injury post shoulder manipulation, one of which included a fracture of the proximal humerus [25]. Arthroscopic findings post manipulation of hemarthrosis, tearing of the joint capsule or rotator cuff, SLAP lesions, labral tears, MGHL rupture or even chondral fragment have been described [26].

Codman's paradox refers to the movement occurring in the shoulder, which is seemingly impossible.

It was described by E. Amory Codman in 1934 and features the rotation of the arm around the shoulder without performing rotational movement [27]. Codman proposed that the completely elevated humerus could be shown to be either in extreme external rotation or in extreme internal rotation, without actually performing a distinct rotational movement. The paradox leads to an apparent 180 degree rotation in the shoulder when performing two sequential axial movements. The sequence of movements defines the rotational position of the shoulder, either external or internal rotation (Fig. 1a, b). We utilise this unique feature of Codman's paradox to perform safe manipulation under anaesthetic to achieve full range of motion in frozen shoulder. In this setting, manipulation of the shoulder under anaesthesia avoids any rotational torque on the humerus, thereby minimising the risk of iatrogenic fractures and associated complications during the manipulation.

The aim of this study is to describe the technique of manipulation under anaesthesia utilising the principle of Codman's paradox, to explain the biomechanical background of the technique and assess the early recovery phase.

## Patients and methods

This is a retrospective review of the prospectively collected data, of 212 consecutive series of patients (224 shoulders) that underwent MUA for frozen shoulder as sole procedure with this technique using Codman's paradox between December 2005 and October 2013. There were 85 males (88 shoulders) and 127 females (136 shoulders). Twelve patients had bilateral procedures, four of which had bilateral MUA during the same procedure. In 96 patients the affected side was the right, and in 128 it was the left. Right hand dominance prevailed in the case of 170 patients, ten left hand dominant, one ambidextrous and 31 not specified.

The mean age was 52.4 years. The aetiology was diabetic frozen shoulder in 39 (13 type 1 IDDM, 26 type 2 NIDDM), 62 following a history of minor trauma or strain and 123 idiopathic frozen shoulder. Patients were referred to our institution after failure of non-surgical treatment modalities such as pain killers, NSAID's, steroid injection, physiotherapy. The mean duration of symptoms leading to the first consultation was 7.21 (±5.2) months. The mean duration of symptoms leading to MUA was 8.81(±5.47) months.

## Manipulation under anaesthetic technique

The procedure is performed with the patient in supine position under general anaesthetic and interscalene nerve block. Shoulder passive range of motion was recorded. The surgeon grasps the upper arm with his hand close to the axilla and his forearm against the patient's arm, the surgeon's contralateral hand stabilises the scapula superiorly thus creating a very short lever arm. The patient's arm is then elevated in the plane of the scapula (Fig. 2a). Usually, an audible tearing sound from the inferior capsule is noted. At that stage, when the arm is in full elevation it is in full external rotation as well. The arm is then brought

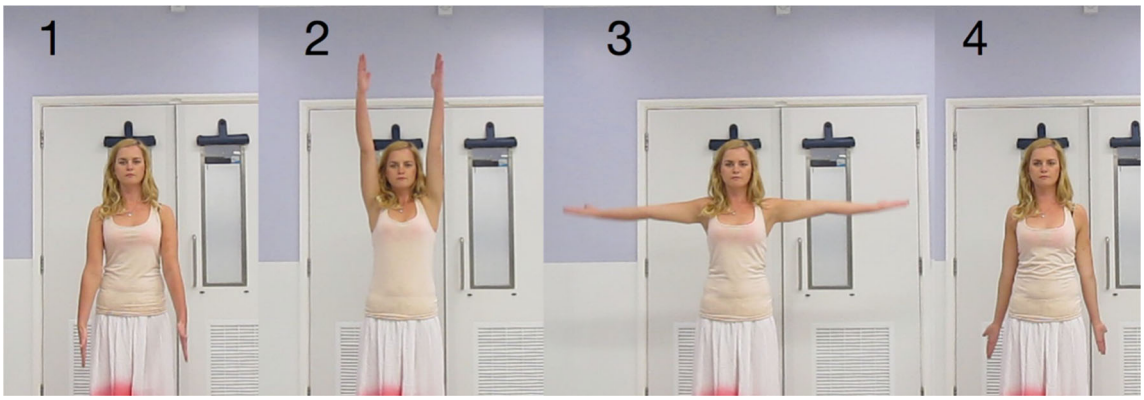


**Fig. 1** Demonstration of the Codman paradox. Series of photos of sequence of movements: 1. Prior to any movement, the arms are on the sides with the palms towards the thighs, thumbs pointing forwards. 2. Full forward flexion. 3. From full elevation, bringing the arms down on the sides (without performing any rotation movement)..., yet, 4. The palms are facing outwards, thumbs pointing to the back. An apparent 180 degrees of external rotation occurred in the shoulder

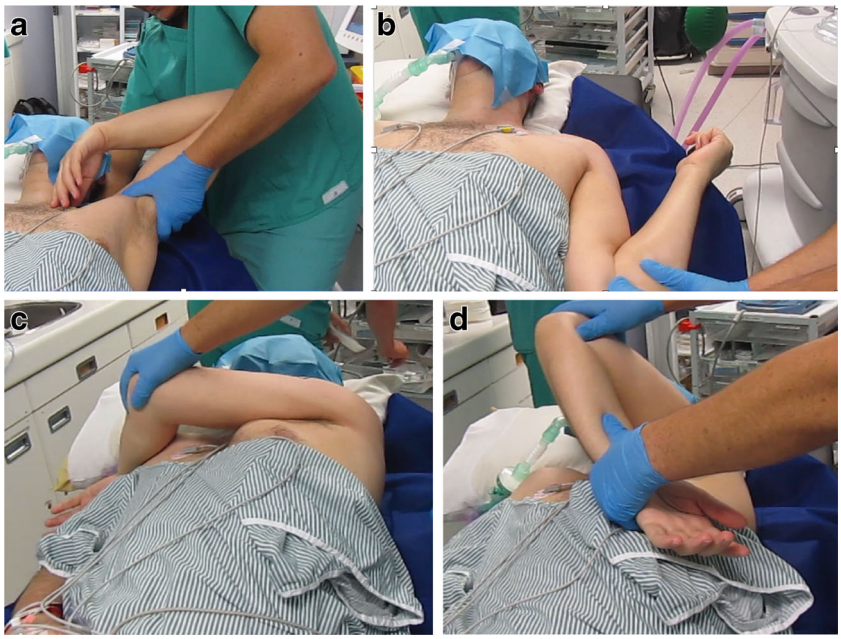


**Fig. 2** **a** Elevation of the arm in the plane of the scapula while stabilising the scapula with very short lever arm. **b** Bringing the arm that is in full external rotation down by the side without any rotation, thus, tearing the anterior capsule. **c** Adducting the arm across the body to extend the tear to the posterior capsule. **d** Holding the arm in internal rotation and cross adducting without any rotation to complete the tear of the posterior-superior capsule

down whilst maintaining its position in full external rotation, to complete the tearing of anterior capsule (Fig. 2b). The arm is subsequently adducted across the patient's chest to extend the tear to the posterior capsule (Fig. 2c) and finally the arm is held in internal rotation (Fig. 2d) and adducted across the body to complete the posterior and superior capsule tear.

Following the manipulation, 10 ml of 0.25% bupivacaine and 40 mg of methylprednisolone acetate are injected into the glenohumeral joint. All patients initiated an immediate physiotherapic treatment with encouragement of full range of active and passive motion.

## Data collection

All the patients were evaluated clinically, pre-operatively and post-operatively, at three weeks and three months, for Constant-Murley functional shoulder score [28] (CS), pain score (VAS), range of motion (ROM), patient satisfaction and subjective shoulder value (SSV). The return to employment or daily activities, the return to sports and leisure activities, and the degree of sleep disturbance were assessed as well before surgery and at each follow-up appointment at three weeks and three months after the procedure.

## Statistical analysis

Statistical analysis of the data was carried out with the $\chi^2$ or Fisher exact test for categorical variables and Student t tests or ANOVA for scale variables, at a significance level of .05. The IBM® SPSS® 21 for Windows was used for all analyses.

## Results

No complications were observed. No fractures, dislocations or nerve injury encountered.

There was immediate improvement in active range of movement following the manipulation. Elevation improved from 91° to 177°, abduction from 73° to 175°, external rotation from 6° to 76°, internal rotation from 17° to 87° and adduction from 17° to 68°, all statistically significant ($p < 0.001$) (Table 1).

At three weeks, there was significant improvement in Constant score from 30.7 (age/gender adjusted 32.0) pre-operatively to 66.0 (age/gender adjusted 68.2). The active range of movement improved significantly with forward elevation (FE) improving from 91° to 154°, abduction (Abd) from 69° to 150°, active internal rotation (AIR) from 12° to 62°, and active external rotation (AER) from 10° to 46°. Pain score and SSV improved from 4.4/15 to 9.6/15 and 1.5/10 to 6.5/10 respectively. All statistically significant ($p < 0.001$) (Table 1). Of patients 45% felt "much better" than before the procedure, 52% felt better, 2% felt the same whilst only 2% felt worse than before. Of patients 78% returned to the same normal level of their occupation or daily activities, as prior to the frozen shoulder, within the first three weeks after MUA.

At three months, the Constant score rose to 70.0 (age/gender adjusted 73.7). The active range of movement improved to 160° of forward elevation, 156° of abduction, 66° of active internal rotation and 50° active external rotation. Pain score and SSV improved to 10.4/15 and 6.7/10 respectively. All statistically significant ($p < 0.001$) (Table 1). At three months, 85% of patients returned to their normal (pre frozen shoulder) level of occupation and activities; 58% of patients felt much better than before the procedure, 38% felt better, 3% felt the same whilst only 1% felt worse than before.

**Table 1** The improvement in scores and range of movement of the shoulder over time

| Examination Under Anaesthetic | Pre Manipulation | Immediately Post Manipulation* | 3 Weeks Post Manipulation | 3 Months Post Manipulation | P value |
|---|---|---|---|---|---|
| Constant Score | 30.7 | | 66.0 | 70.0 | <0.001 |
| Age/Sex adj. Constant score | 32 | | 68.2 | 73.7 | <0.001 |
| VAS pain | 4.4/15 | | 9.6/15 | 10.4/15 | <0.001 |
| SSV | 1.5/10 | | 6.5/10 | 6.7/10 | <0.001 |
| Elevation | 91° | 177° | 154° | 160° | <0.001 |
| Abduction | 73° | 175° | 150° | 156° | <0.001 |
| External Rotation | 6° | 76° | 46° | 50° | <0.001 |
| Internal Rotation | 17° | 87° | 62° | 66° | <0.001 |

*Passive ROM

The improvements of the Constant score and the range of motion over the initial three weeks post-operative were very steep, with further modest improvements in the following period to three months after the manipulation. The diabetic frozen shoulder group of patients, clearly benefited from the procedure, but showed a slower recovery rate and lower score values, as well as a slight regression in all parameters at three months compared to the initial improvements while patients with trauma associated frozen shoulder showed similar trend of improvement to the idiopathic frozen shoulder group.

## Discussion

The importance of early recovery in frozen shoulder is crucial and ameliorates an individual's quality of life significantly. Furthermore, it accelerates return to work, thus shortening economic burden. The natural history of the frozen shoulder remains controversial. Although it has previously been postulated [27] that the majority of patients will eventually have complete resolution of the disease in two to three years, others [2, 3, 29] report long-term pain and residual loss of motion.

Shaffer et al. [2] reported on 62 patients with a mean follow-up of seven years, in which 50% of the patients still had residual pain or loss of motion at the time of latest follow-up. Hand et al. [29] described that 41% of the patients with frozen shoulder reported some ongoing symptoms at long term follow-up ranging up to 20 years (mean 4.4 years (range 2–20 years). Only 59% of the patients had normal or near normal shoulders at that long term follow-up of frozen shoulder. Griggs et al. [30] showed satisfactory results with physiotherapy after mean of 22 months follow up, still reporting noticeable differences in the range of motion compared to the contralateral shoulder, as well as somewhat lower DASH score.

Closed MUA has been suggested and used extensively with satisfactory results in both short- and long-term follow-up [15, 16]. However the risk of complications that include humeral fractures, glenoid fractures [21], shoulder dislocation, post manipulation pain, haemarthrosis, subscapularis rupture, labral tears, injury to the biceps tendon or the rotator cuff and traction injury to nerves around the shoulder, have been raised as a caution against the use of MUA for the treatment of frozen shoulder. Quigley [22] reported one fracture of the anatomic neck of the humerus of 44 shoulders manipulated. Hamdan [20] reported out of 110 shoulders manipulated two crack fractures of the surgical neck of the humerus, and two other shoulders which required immediate reduction for glenohumeral dislocation. Magnussen [21] in a case report described a glenoid fracture. Othman [23] reported one shoulder subluxation during the procedure which was immediately reduced, with satisfactory outcome. Birch [24] treated three cases of brachial plexus injury post shoulder manipulation, one of which included a fracture of the proximal humerus [25]. Arthroscopic findings post manipulation of haemarthrosis, tearing of the joint capsule or rotator cuff, SLAP lesions, labral tears, MGHL rupture or even chondral fragment have been described. [26].

Clearly, the term "manipulation under anaesthesia" is general and entails different techniques and not all MUAs are the same. Few of the papers that have dealt with this subject have delineated a specific technique at all. Dodenhoff et al. [15] reported high satisfaction scores and improvement in range of motion following MUA using the same technique utilising Codman's paradox principles, in a prospective level IV study of 39 shoulders. The mean follow up was 11 months (range 6–18 months). Patients were

satisfied for regaining the ability to do daily tasks, which most could do within days of the manipulation.

Farrell [16] et al. reported that patients showed sustained improvement in both pain and range of motion in the long-term following MUA at 15 years. Wang [31] et al. described the short and long term effects of MUA on diabetic and non-diabetic frozen shoulders as a simple and non-invasive procedure that improves symptoms and shoulder function within a short period of time with no recurrences.

Understanding Codman's paradox has enabled us to provide a safe, simple and consistent method of MUA using short lever arm and avoiding perilous rotational torque, with excellent short-term results.

We have used a simple, safe and efficient technique for MUA for treatment of frozen shoulder that follows the principles of Codman's paradox. This technique avoids any rotational torque on the humerus or the various structures in and around the shoulder joint, thereby minimising the risk of iatrogenic fractures and associated complications during the manipulation.

The outcome of our large, consecutive series of patients with primary frozen shoulder treated with Manipulation under anaesthesia utilising Codman's paradox, shows mean improvement of 36 points on the Constant score at 3 weeks follow-up with no surgical complications. Of the patients 71% returned to work and full activity at three weeks after the MUA, and 79% at three months.

Patient satisfaction improved from mean 1.5/10 pre-operatively to 6.5/10 at three weeks and 6.7/10 at three months post MUA. We report no complications as a result of the MUA in our study. There were no fractures or dislocations, no symptoms of acute rotator cuff tear and no neurological or other iatrogenic injuries. There were no short- or long-term adverse clinical events in our patients.

Our study includes the results of MUAs performed by the senior author, as well as, by shoulder fellows and trainees. It is a safe and easily learned technique. This technique, if conducted properly, is safe, reproducible and effective and provides rapid and excellent clinical results.

## Conclusion

The use of Codman's paradox to perform manipulation under anaesthesia to treat shoulder contracture in frozen shoulder provides a safe, reproducible and efficient treatment. It results in dramatic early improvement in ROM, functional outcomes and high satisfaction, as early as three weeks post-operatively.

#### Compliance with ethical standards

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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