

# Shoulder Passive Motion Rehabilitation Utilizing a Continuous Passive Motion Device following Surgical Release or Manipulation Under Anesthesia; A Review

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## ABSTRACT

### Background

Post-operative rehabilitation of the shoulder following a surgical release or manipulation under anesthesia consists of a period of passive motion (PM) to prevent adhesions, the detrimental effects of immobilization, reduce pain, reduce inflammation and increase range of motion to a functional level. Continuous passive motion (CPM) devices have been used routinely as a PM modality.

### Objectives

To determine, with evidence from peer-reviewed journals, the optimal rehabilitation strategy, including the use of CPM, after a release of a contracted joint.

### Search strategy

The search included MEDLINE (1980 to 2005), JBJS (1974 to 2005), AJSM, Sage Publications (1976 to 2005), Lippincott Williams & Wilkins online journals, Springerlink.com online journals, NCBI.nlm.nih.gov (database), elsevier.com (Elsevier Health Science Periodicals) and reference lists of articles.

### Selection criteria

All peer-reviewed clinical studies for rehabilitation that included a CPM device after a surgical release or a manipulation under anesthesia for a contracted joint.

### Main results

Sixteen studies following a release of a contracted joint were included. Data were not pooled. In all studies, CPM demonstrated either statistically significant (11 studies) or positive functional (5 studies) outcomes for subjective and objective measures. The outcomes evaluated were overall function, range of motion, compliance, and cost effectiveness. CPM was superior to physical therapy alone or contracture splinting alone (6 studies). Six studies reported on duration of CPM use. Five studies reported six or more weeks of use and one study reported four weeks of use in order to reach significant results.

### Author's conclusions

CPM regimens are widely employed in rehabilitation after a surgical release or a manipulation under anesthesia of a contracted joint. This review found sufficient evidence from peer-reviewed clinical studies that rehabilitation programs that include CPM is the best strategy.



## POSTOPERATIVE CPM FOLLOWING JOINT SURGICAL RELEASE OR MANIPULATION UNDER ANESTHESIA (Shoulder, Elbow, Hand)

### INTRODUCTION

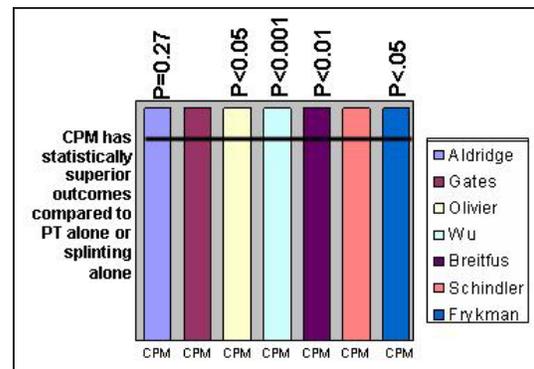
CPM after the surgical release of a joint contracture has been used extensively in the shoulder, elbow, and hand.<sup>60</sup> Clinical studies have demonstrated that CPM alone, CPM compared to splinting alone or CPM combined with physical therapy have resulted in superior statistical outcomes over programs without CPM.<sup>4,13,14,35,41,52</sup>

The initial goal of therapy following a surgical release of a contracted joint is to maintain the range-of-motion gained after the release. If passive motion is not started within the first 48 hours following the release the prognosis for improvement is significantly diminished.<sup>13</sup> O'Driscoll and Giori<sup>93</sup> have demonstrated that CPM immediately following a surgical release acts to pump blood and edema fluid out of the joint and periarticular tissues. The reduction of these fluids from a synovial joint reduces the risk of post-surgical joint stiffness. A contracted joint typically has an inflammatory component which can be aggravated by the surgical release itself resulting in limited or no improvement in range-of-motion following the surgical procedure. Salter,<sup>122</sup> Kim,<sup>56</sup> Kreder<sup>59</sup> and Moran<sup>82</sup> have all shown that CPM has reparative effects on inflamed joints. However, until recently the mechanism by which CPM acts as an anti-inflammatory agent was unknown. Recent studies by Gassner,<sup>40</sup> Lee,<sup>63</sup> Xu<sup>144</sup> and Ferretti<sup>33</sup> have helped explain the molecular basis for the beneficial effects of CPM on the inflamed joint. A CPM device by applying cyclic tensile stress on the involved joint for an extended time counteracts the effects of the inflammatory agents even better than immobilization.

The efficacy of CPM following a joint release in either the shoulder, elbow, or hand is clearly demonstrated in the following peer-reviewed studies. CPM leads to greater functional outcomes, greater ROM, improved healing by acting as an anti-inflammatory agent and higher patient satisfaction. The duration of CPM use is determined by the severity of the contracture and as long as improvements are seen.

### EFFICACY OF PEER-REVIEWED POST SURGICAL RELEASE CPM STUDIES

A search in peer-reviewed medical journals for clinical studies involving the use of continuous passive motion following the release of a contracted joint revealed ten elbow, five shoulder and one hand study. In all studies the primary finding was that the use of CPM for passive motion following a surgical joint release resulted in both objective and subjective positive outcomes for overall function, range of motion, compliance and cost effectiveness.<sup>4,8,10,12,35,41,52,60,85,99,100,126,136</sup> Postoperative rehabilitation protocols that included CPM are proven to be statistically more effective than protocols that did not include CPM (compared to physical therapy, splinting, and patient directed exercises).<sup>4,13,35,41,52,126</sup>



**Figure 1**  
CPM and PT only or splinting only comparative studies. CPM is statistically superior to both PT alone and splinting alone.

### ELBOW

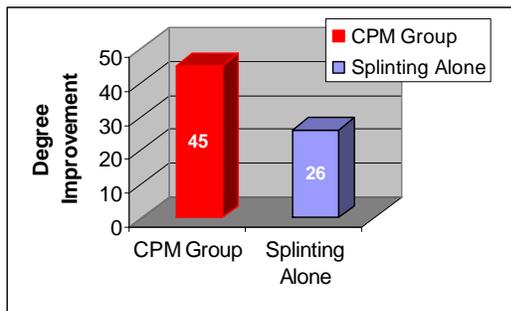
1. Aldridge JM, Atkins T, Gunneson EE, Urbaniak JR; Anterior release of the elbow for extension loss. *J Bone Jt Surg. 86A (9):1955-60, 2004.*

The purpose of this study was to report the outcomes of surgical correction, predominantly with an anterior release, of elbow flexion contractures. In addition, the author's evaluated the efficacy of continuous passive motion use for four weeks or more depending on the severity of the contracture. The author's retrospectively

reviewed the outcomes of 106 consecutive patients who had undergone anterior elbow release for the treatment of a flexion contracture between July 1975 and June 2001. Twenty-nine patients were excluded because they had been followed for less than twelve months, leaving a study group of seventy-seven patients. Postoperatively, fifty-four of the seventy-seven patients were treated with continuous passive motion and the other twenty-three patients were treated with extension splinting. The average duration of follow-up was thirty-three months. The average patient age was thirty-four years. The results were evaluated on the basis of both preoperative and postoperative radiographs as well as clinical measurements of elbow motion, all performed by the same examiner using the same large (47-cm-long) goniometer.

Results: The mean preoperative extension in the seventy-seven patients was 52°, which decreased to 20° postoperatively. The mean flexion increased from 111° preoperatively to 117° postoperatively, and the mean total arc of motion increased from 59° to 97°. The total arc of motion in the patients treated with continuous passive motion increased 45°, compared with an increase of 26° in those treated with extension splinting (P=0.27).

The primary result is the release of a pathologically thickened anterior elbow capsule through a predominantly anterior approach to correct diminished elbow extension is a safe and effective technique. Furthermore, compared with splinting in extension alone, the utilization of continuous passive motion during the postoperative period resulted in a statistically significant increase in the total arc of motion (Figure 2).

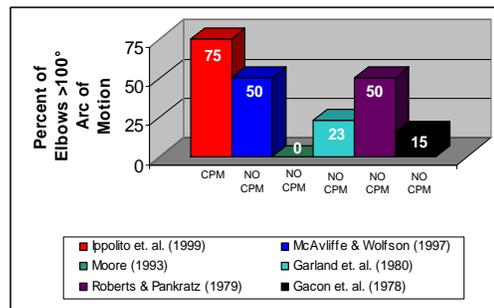


**Figure 2**  
CPM following a surgical release offers statistically superior functional outcomes over splinting and physical therapy without CPM. (p=0.27)

2. Ippolito E, Formisano R, Caterini R, Farsetti, P, Paneta F; Resection of elbow ossification and continuous passive motion in postcomatose patients. *J Hand Surg. 24A(3): 546-53, 1999.*

Heterotopic periarticular ossifications were surgically excised in 16 elbows of 14 traumatic brain injury patients an average of 18.9 months (range, 4-67 months) after the end of coma. In 11 elbows the ulnohumeral joint was ankylosed in a position that ranged from 0° to 100° of flexion (group 1); in 5 elbows the arc of flexion ranged from 10° to 25° (group 2). Full pronation and supination were present in 15 of the elbows; in 1 the radiocapitellar joint was fixed at 30° of pronation by a partial ossification of the interosseous membrane. The arc of flexion attained after surgery averaged 115° (range, 90° to 145°) in the group 1 elbows and 128° (range, 115° to 140°) in the group 2 elbows. In an attempt to prevent postoperative loss of motion and recurrence of ossification, continuous passive motion was applied to the affected elbow for 6 weeks before starting a fully active rehabilitation program. All the patients were examined at regular intervals after the surgery. The follow-up period ranged from 12 to 60 months (average, 30.7 months). During the follow-up period, all the elbows showed improvement in range of motion and the arc of flexion averaged 95° (range, 30° to 135°) in the group 1 elbows and 116° (range, 80° to 145°) in the group 2 elbows.

The primary finding is that the author's results were superior with CPM when compared to previous investigators who did not use CPM for 6 weeks postoperatively (Figure 3).<sup>36,37,70,81,103</sup>

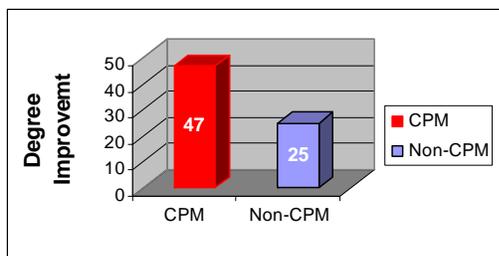


**Figure 3**  
CPM is a more effective in reaching functional ROM than a rehab program with out CPM following the release of a stiff joint.

3. Gates H, Sjullivan F, Urbaniak J: Anterior capsulotomy and continuous passive motion in the treatment of post-traumatic flexion contracture of the elbow; A prospective study. *J Bone Jt Surg. 74A(8): 1229-39, 1992.*

Thirty-three patients who had a post-traumatic flexion contracture of the elbow were managed consecutively with anterior capsulotomy without tenotomy of the biceps tendon or myotomy of the brachialis muscle. The first fifteen patients (Group I) did not receive continuous passive motion postoperatively. Preoperative active extension for Group I was an average of 48° short of full extension, which improved to 19° at a mean follow-up time of forty-five months. Subsequently, eighteen patients (Group II) received continuous passive motion postoperatively for a mean of six weeks. Preoperative active extension for Group II was on average 55° short of full extension, which improved to 23° at a mean duration of follow-up of thirty-five months. The mean preoperative arc of motion for Group I was 69°, which improved to 94° postoperatively. The mean preoperative arc of motion for Group II was 48°, which improved to 95° postoperatively. Five patients in Group I and six patients in Group II had severe preoperative heterotopic ossification. There was no correlation, however, between preoperative heterotopic ossification and the amount that extension of the elbow improved postoperatively. There was no postoperative increase in heterotopic ossification (Figure 4).

The primary finding is the use of CPM on average for six

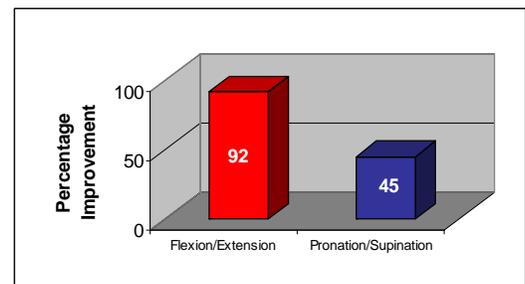


**Figure 4**  
CPM for 6 weeks postop resulted in a statistically significant improvement in function.

weeks post-operatively improved the total arc of motion following an anterior capsulotomy by 47° compared to 25° for the non-CPM group. The difference between the groups was statistically significant.

4. Olivier LC, Assenmacher S, Setareh E, Schmit-Neveburg KP: Grading of functional results of elbow joint arthrolysis after fracture treatment: *Arch Orthop Trauma Surg. 120:562-569, 2000.*

In the treatment of post-traumatic contracture of the elbow joint, arthrolysis is a proven procedure. A stepwise operative approach was used starting laterally and including an additional medial and dorsal incision if needed. A total of 91 patients with arthrolysis of the elbow could be followed-up on average of 44 months (range 9-102 months) after operative (58, 63.7%) and non-operative (33, 36.3%) fracture treatment. The mean preoperative range of motion (ROM) in flexion/extension was 49° (SD ± 38°), while in pronation/supination it was 89° (SD ± 66°). Postoperatively, the ROM was on average 94° (SD ± 27°) in flexion/extension and 129° (SD ± 52°) in pronation/supination. Using our own grading system, it became evident that most patients had a functional benefit from the procedure, although the quality of the improvement differed. For example, postoperatively 59.3% of the patients were grade I (90°) in flexion/extension compared with 16.5% preoperatively (Figure 5).



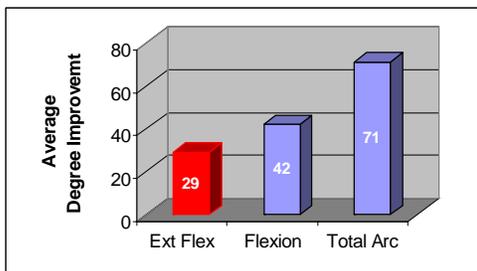
**Figure 5**  
CPM was statistically significant following the surgical release of a joint ( $p < 0.05$ ).

The earlier the release of the joints was performed; the better was the functional outcome ( $p < 0.05$ ). The importance of an intensive early continuous passive motion program is emphasized while indication for this procedure should only be seen in compliant patients.

5. Wu CC: Posttraumatic contracture of the elbow treated with intraarticular techniques; *Arch Ortho Trauma Surg. 123(9): 494-500, 2003.*

Posttraumatic contracture of the elbow is very disabling. However, an absolutely convincing surgical technique has not been defined

in the literature. We developed an intraarticular technique to concomitantly treat both intraarticular and extra-articular lesions with one posterior incision. Twenty consecutive adult patients were treated with anteroposterior capsule release. Immediately post-operatively, continuous passive motion was initiated. All 20 patients were followed up for median of 3.8 (range 2.1-2.2) years. The satisfactory rate was 95% (19 of 20,  $p < 0.001$ ). The flexion contracture improved from an average of  $42^{\circ}$  to  $13^{\circ}$  which was statistically significant ( $p < 0.001$ ), and maximal flexion improved from an average of  $89^{\circ}$  to  $131^{\circ}$  ( $p < 0.001$ ). The arc of motion improved from an average of  $47^{\circ}$  to  $118^{\circ}$  ( $p < 0.001$ ). The sole unsatisfactory patient still had  $20^{\circ}$ - $110^{\circ}$  arc of motion. There were no evident complications noted (Figure 6).



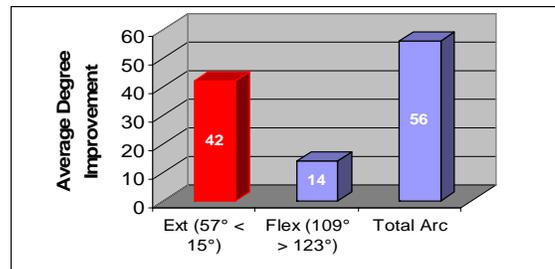
**Figure 6**  
Statistically superior improvement due to the use of CPM post fracture.

The primary finding is the surgical technique resulted in a high satisfaction rate, low complication rate and a statistically significant improvement in ROM with the use of CPM post-operatively.

6. Bae DS, Waters P: Surgical treatment of posttraumatic elbow contracture in adolescents; *J Ped Ortho.* 21(5): 580-584, 2001.

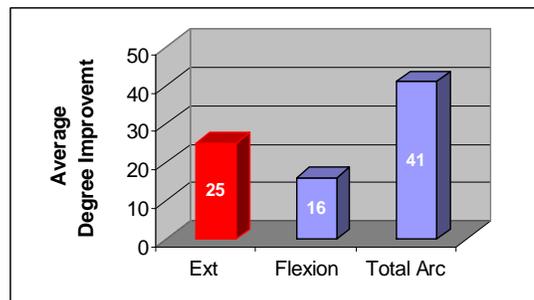
Thirteen adolescent patients with posttraumatic elbow contractures were treated with open surgical release at an average of 16.2 years of age. When possible, an extensile medial approach to the elbow was used. All patients were treated with 6 weeks of postoperative continuous passive motion. Eleven patients with  $>6$  months of follow-up were evaluated at an average of 29 months after surgery. Average loss of extension improved from  $57^{\circ}$  to  $15^{\circ}$ , and average flexion improved from  $109^{\circ}$  to  $123^{\circ}$ . Average total arc of motion improved from  $53^{\circ}$  to  $107^{\circ}$  (Figure 7).

The primary finding by the author is functional ROM was reached (great then a  $100^{\circ}$  arc) on average with the use of CPM postoperatively for 6 weeks.



**Figure 7**  
The CPM grouped reached the functional ROM level of  $100^{\circ}$  more often compared to the non-CPM group which did not reach the functional ROM level as often.

7. Phillips B, Strasburger S; Arthroscopic treatment of arthrofibrosis of the elbow joint. *J Arthro Rel Surg.* 14(1), 1998.

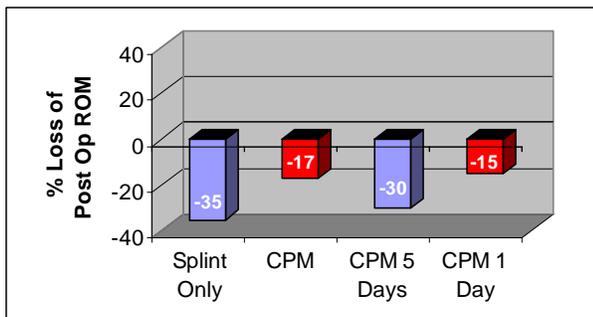


**Figure 8**  
ROM improvements were statistically superior to protocols that did not use CPM post-op.

Twenty-five patients with arthrofibrosis of the elbow were treated with arthroscopic debridement followed by post-operative use of CPM; 15 had post-traumatic arthrofibrosis and 10 had contractures caused by degenerative arthritis. At an average follow-up of 18 months, all patients had increased motion and decreased pain. One patient required re-operation because of continued stiffness and pain; she had moderate pain before surgery, mild pain after initial debridement, and occasional mild pain after the second operation. Patients with post-traumatic arthritis had more severe flexion contractures preoperatively than did those with degenerative arthritis, but they also had more improvement postoperatively (Figure 8).

The primary finding of this study is arthroscopic release and debridement of arthrofibrotic elbow joints followed by the use of CPM obtained improvements equal to that obtained by open techniques, with less morbidity and earlier rehabilitation. Range-of-motion improvements were statistically significant ( $P=0.001$ ).

8. Breitfus H, Muhrg G, Neuman K, Rehn; Arthrolysis of post-traumatic stiff elbow; Which factors influence the end result. *Unfallchirurg. 94(1):33-9, 1991.*



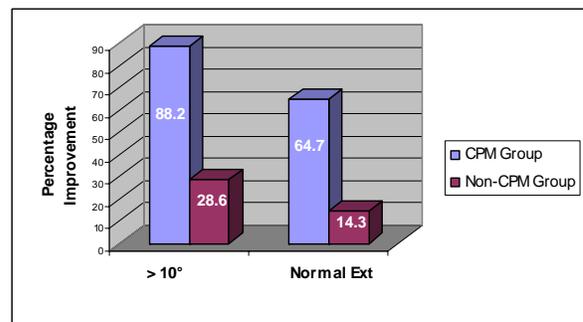
**Figure 9**  
Statistically superior results were obtained when CPM was applied with in 48 hours compared to a delayed application. Delayed CPM use was superior to non-CPM protocols.

The results obtained with elbow arthrolysis performed for the treatment of posttraumatic stiffness were analyzed via a retrospective study of 59 patients. The intra-operative functional result was classified as excellent in all cases, while on average 27 months after the operation the range of movement was decreased again to varying extents. This deficit correlated with the type of injury, timing of arthrolysis, duration of metal implants and timing and type of postoperative rehabilitation program. The relative increase in function was better after simple fractures, with 47%, than after fracture dislocations, with 35%. After arthrolysis within 3 months of onset of posttraumatic stiffness the range of improvement was 55%, compared with an increase of only 30% after 10 months' stiffness. When arthrolysis was combined with metal removal and the implants had been in place for longer than 9 months the increase achieved was only 15%. Patients started on CPM on the 1<sup>st</sup> day postoperatively lost only 15% of their intra-operative function. If CPM was delayed to between the 2<sup>nd</sup> and 5<sup>th</sup> day, 30% was lost. Utilizing a splint program for maximal joint flexion and extension at 4-hour intervals instead of CPM resulted in a 35% loss of range of

movement postoperatively. In contrast there was a loss of only 17% in the group with combined physiotherapy and continuous passive motion (Figure 9).

The results show that the prognosis of elbow arthrolysis is determined by early mobilization with a CPM device and optimal operative planning. The time to arthrolysis should be as short as possible, as should the time to removal of metal implants. The aim of the rehabilitation program is immediate postoperative continuous passive motion.

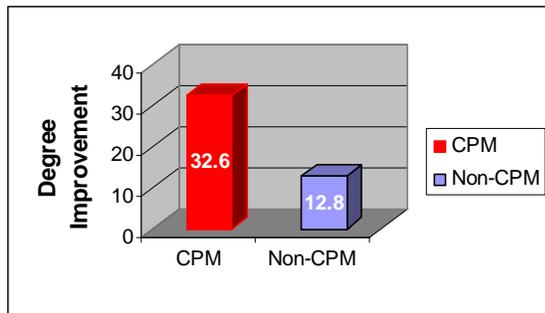
9. Schindler A, Yaffe B, Chetrit A, Modan M, Engel J: Factors influencing elbow arthrolysis. *Ann Chir Maine Super. 10(3): 237-42, 1991.*



**Figure 10**  
CPM group reached functional ROM more often than non-CPM use and the difference was statistically significant ( $p < 0.001$ ).

Over the period 1982 to 1988, 31 consecutive patients at the Hand Surgery Unit of the Sheba Medical Centre were subjected to elbow joint arthrolysis to treat restriction of range of motion solely due to trauma. This retrospective study aims to evaluate the relative influence of the following factors on functional outcome: sex, age, type of original injury and initial management, presences of para-articular ossification, delay between injury and arthrolysis, and the use of manipulation and a continuous passive motion device (CPM) following surgery. The range of motion was recorded prior to arthrolysis and after operation (excluding one patient who subsequently underwent arthrodesis for intractable pain). Follow-up averaged 15.3 months ( $\pm 5.4$ ). In the 24 patients with extension deficit ( $>20^\circ$ ), the mean improvement was of  $26.9^\circ$  ( $>23.1^\circ$ ); in the 21 patients with flexion deficit the mean improvement was  $21.2^\circ$  ( $>18^\circ$ ). The mean improve-

ment for total range of motion in the series overall was 35.2° ( $\pm 23.8^\circ$ ). 90% showed an improvement of at least 10° and 30% attained normal ROM. All of these improvements in range were highly statistically significant (figure 10) ( $p < 0.0001$ ) (Figure 10).



**Figure 11**  
CPM was the only variable that specifically resulted in a statistical improvement.

With regard to improvement in extension, the only variable of value was the use of a continuous passive motion device following surgery; those patients subjected to CPM showed a mean improvement of 32.6° ( $\pm 19.0^\circ$ ), while those without averaged 12.8° ( $\pm 27.5^\circ$ ) ( $p < 0.01$ ). Respective rates of improvement beyond 10° were 88.2% vs. 28.6%, while the respective incidences of patient attaining normal extension were 64.7% vs. 14.3% ( $p = 0.03$ ) (Figure 11).

*10. Tsionos, I, Leclercq C, Rochet JM; Heterotopic ossification of the elbow in patients with burns: Results after early excision. J Bone Joint Surg Br. 86-B:396-403, 2004.*

Heterotopic ossification which may develop around the elbow in patients with burns may lead to severe functional impairment. We describe the outcome of early excision for heterotopic ossification undertaken as soon as the patient's general and local condition allowed. The mean age at operation was 42 years. The mean area of burn surface burns was 40%. The mean pre-operative range-of-motion (ROM) was 22° in flexion/extension and 94° in pronation/supination. The mean time between burn and surgical release was 12 months with a median of 9.5 months. The mean follow up period was 21 months.

Between 1992 and 2001, a consecutive series of 28 patients with 35 elbow burns underwent a surgical release due to heterotopic

ossification. All procedures were performed by the same surgeon followed by continuous passive motion (CPM) starting on the second postoperative day. The CPM was used for eight hours a day for three to four weeks with diminished daily use for another two to four weeks for a total of five to eight weeks. The CPM device was used as needed to gain ROM or to preserve ROM gained from the surgical release.

The gains in ROM were statistically significant improving from a mean of 22° to 123° in flexion/extension and a mean of 94° to 160° in pronation/supination. The improvement in ROM reached 100° in the total flexion/extension arc and 100° in the pronation/supination arc which is considered the minimum to perform most daily activities. The authors conclude that early excision of elbows with heterotopic ossification following a severe burn followed by CPM is recommended to reach functional ROM.

## SHOULDER

*11. Bradley JP: Arthroscopic treatment for adhesive capsulitis. Operative Techniques in Orthopaedics. 1(3), 248-252, 1991.*

This initial report describes the use of arthroscopy and subsequent manipulation followed by the postoperative use of continuous passive motion with fifteen patients who have primary adhesive capsulitis. CPM is initiated in the recovery room and is increased at home as comfort permits with use of at least ten hours per day.

This preliminary study demonstrated the safety with positive results for CPM following manipulation under anesthesia for adhesive capsulitis.

*12. Matsen Fa: Open release for posttraumatic stiff shoulder. Video Journal of Orthopedics 7012: August, 1991.*

Operative release is considered when motion is limited because of conditions such as motion interface adhesions or contracture of the subscapularis. Dr. Matsen reviews the principles and procedures common to every shoulder release surgery, specifically, the mobilization of the motion interface, coronal plane Z-plasty lengthening of the subscapularis, and 360-degree release of the subscapularis. In addition, he discusses his postoperative management. Dr. Matsen is professor of orthopaedics at the University of Washington

School of Medicine and chief of the orthopaedic service at the University of Washington Hospital, both in Seattle. He is currently a member of the VJO editorial board and formerly served as president of the Shoulder and Elbow Society.

*“Continuous passive motion is begun in most patients directly after the operation. The purpose is to retard or discourage adhesion development. During the surgery, a brachial plexus block technique is used that provides 12 to 18 hours of postoperative analgesia. This enables patients to learn directly after the operation, while pain is reduced, that range of motion is restored. As a result, most become dedicated to self-rehabilitation.”*

*13. LaStayo P, Jaffe, R: Assessment and management of shoulder stiffness: A biomechanical approach. Journal of Hand Therapy April-June, 1994.*

This article discusses the loss of shoulder motion, anatomical and biomechanical considerations, and treatment methods. CPM as a low load, prolonged stress device supports Dr. Salter's findings that CPM overcomes joint stiffness.

The primary finding is that CPM is successful in reducing joint stiffness by modulating pain, decreasing muscle spasm, decreasing effusion and decreasing edema.

*14. Bennet WF: Addressing glenohumeral stiffness while treating the painful and stiff shoulder arthroscopically. The Journal of Arthroscopic and Related Surgery 16(2), March, 2000.*

The shoulder can be primarily or secondarily stiff. Cadaver studies have shown increases in passive range of glenohumeral motion when certain portions of the capsule are released. This study has recorded the intraoperative gains made in passive range of motion for external rotation, flexion, abduction, and internal rotation with sequential release of the rotator interval, inferior capsule, and posterolateral capsule, regardless of initial etiology and follow-up over time. A shoulder CPM device was a primary tool for passive range of motion therapy. Thirty one of 60 shoulders, found clinically to have a loss of passive range of motion and having failed a nonoperative approach, underwent a capsular release. Eighteen patients underwent a partial capsular release (group 1) and 13

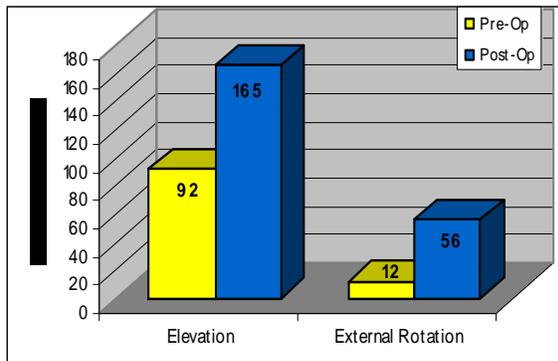
patients (group 2) underwent a complete capsular release. Thirty of 31 shoulders had statistically significant gains in passive range of motion with sequential release. In general, resection of the rotator interval contributed to gains in external rotation; resection of the inferior capsule (anteroinferior and posteroinferior) contributed gains to external rotation, forward flexion, and internal rotation; and resection of the posterolateral capsule contributed to gains only in internal rotation. At a minimum of 18 months follow-up, 30 of 31 shoulders retained their intraoperative gains ( $P > .05$ ).

The primary finding is that an arthroscopic release of capsular tightness is beneficial in returning shoulders with a loss of passive glenohumeral motion to normal regardless of the etiology. A secondary finding is that CPM use was a primary factor in the results achieved.

*15. Nicholson GP: Arthroscopic Capsular release for stiff shoulders effect of etiology on outcomes. The Journal of Arthroscopy and Related Surgery 19(1): January, 2003.*

The etiology, pathogenesis, time course, and response to treatment of stiff shoulder pathology are still under investigation and debate. This prospective study evaluated arthroscopic capsular release to treat stiff shoulder pathology that was resistant to conservative management. The etiology of the shoulder stiffness was categorized and analyzed for effect on outcomes.

In 68 stiff shoulders (41 women, 27 men) that underwent arthroscopic capsular release, 5 distinct etiologies were identified: postsurgical in 20, idiopathic in 17, post-traumatic in 15, diabetic in 8, and impingement syndrome (prior primary impingement developing stiffness) in 8. Average age was 50 years (range, 29-72), and follow-up averaged 3 years (range, 2 to 8). Prior to this procedure, duration of symptoms averaged 7.3 months (range, 3 to 48), and formal physical therapy averaged 3.7 months (range, 1 to 12). Preoperative average American Shoulder and Elbow Surgeons Score (ASES) was 35.5 (range, 10 to 77), medial Simple Shoulder Test (SST) was 3 (0 to 10), and median Visual Analog Score (VAS) for pain was 6 (0 to 10). Average active forward elevation (FE) was 92°, external rotation (ER) at side was 12°, and medial-internal rotation (IR) was to the buttock (Figure 12). All patients underwent arthroscopic capsular release with continuous passive motion postoperatively.



**Figure 12**  
Shoulder ROM gain was statistically significant following the use of CPM postoperatively (p<.0001).

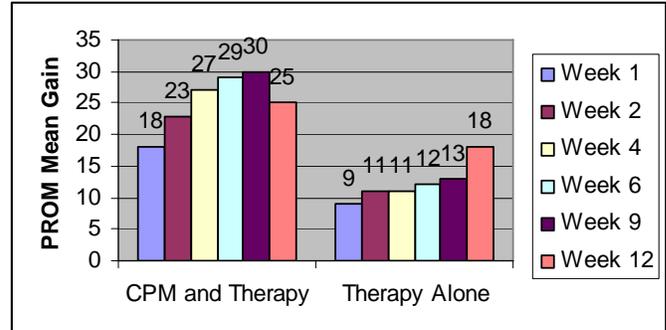
The study population showed significant improvement (P < .0001) for all outcome scores and active motion parameters. Average and median outcome parameters for the population, with improvement in parenthesis were: ASES 93 (+57.5), SST 10 (+7), VAS 0 (-6), FE 165° (+73°), ER at side 56° (+44°), and IR to T-12 (+7 spinal segments). The time in formal physical therapy averaged 2.3 months (2 to 20 weeks) and time to attain final, pain-free range of motion averaged 2.8 months (1 to 6). Outcomes for, and between, each etiology were analyzed.

Stiff shoulder pathology can result from a variety of differing etiologic factors. Arthroscopic capsular release with postoperative CPM was equally effective across the 5 identified etiologic groups, and provided significant pain relief, restoration of motion, and function within an average of 3 months.

HAND

16. Frykman GK, Matsushima D, Waylett-Rendall J, Unsell RS: CPM improves range of motion after PIP and MP capsulectomies; A controlled prospective study. American Society for Surgery of the Hand, 44<sup>th</sup> annual meeting: September, 13-16, 1989.

Continuous passive motion (CPM) has been beneficial following joint surgery and has become a popular postoperative therapy. We are reporting on a controlled prospective study using CPM following capsulectomy of MP and PIP joints of the hand (Figure 13)



**Figure 13**  
ROM gains were statistically superior when CPM was part of the postop protocol.

All patients had capsulectomy of one or more joints for posttraumatic ankylosis. All had failed to improve in range of motion with a vigorous hand rehabilitation program and several had failed a previous capsulectomy procedure that did not include postoperative CPM. Except for CPM, all patients had the same vigorous postoperative hand therapy program begun as soon as possible (usually within one day) postoperatively. They were followed for six months postoperatively. In the study group CPM was used for an average of six weeks postoperatively. Fifty-one joints (30 PIP and 27 MP) were studied in 31 patients. Overall the mean gain in range of motion from preoperative values is found in Table 1.

The gain in passive ROM was greater than active ROM. The pain was less postoperative in the CPM group. There were no significant complications from CPM use.

**Table 1**

Passive ROM			Active ROM		
Weeks PO	CPM	Controls	Weeks PO	CPM	Controls
1	18°	9°	1	2°	1°
2	23°	11°	2	7°	10°
3	26°	11°	3	10°	4°
4	27°	11°	4	12°	1°
6	29°	12°	6	16°	4°
9	30°	13°	9	17°	7°
12	25°	18°	12	16°	10°
26	21°	10°	26	16°	6°

\*Statistically significant p < .05

The primary finding is patients who used CPM following MP and PIP capsulectomy had a statistically significant (P < .05) gain in postoperative passive ROM and active range of motion over a conventional hand therapy program.

### SUMMARY/DISCUSSION

Prior to 1989 there were few reports on the use of CPM following the surgical release of a joint contracture. Frykman<sup>35</sup> reported statistically superior outcomes ( $p < .05$ ) on the use of CPM for stiff MP and PIP joints for posttraumatic ankylosis in 1989. CPM for six weeks in duration was tried after a vigorous hand therapy program had failed or after a previous surgical intervention without CPM had failed. Bradley<sup>12</sup> reported significant positive results with CPM use for 10 hours per day after arthroscopy and manipulation for primary adhesive capsulitis of the shoulder in 1991. Also in 1991, a retrospective study by Breitfus<sup>13</sup> found CPM to be superior to physical therapy and a splinting program. The author also looked at start time and found superior results were seen when CPM was started within 48 hours following the surgical procedure. A second retrospective study was done by Schindler<sup>126</sup> between 1982-1988 and found CPM the only rehabilitation variable of value. CPM was initiated following an arthrolysis procedure for a contracted joint and resulted in a statistically significant improvement ( $p < 0.01$ ) both in range of motion and function (88% of CPM users improved more than 10° while only 29% of non users had similar success).

A study by Gates<sup>41</sup> in 1992 compared physical therapy to a CPM (six weeks) protocol following a release of a joint contracture. The CPM group improved a mean of 47° compared to only 25° in the physical therapy group. Ippolito<sup>52</sup> also reported functional improvements with CPM after six weeks of use compared to a similar series who only utilized physical therapy in 1999. The importance of an intensive early CPM program was emphasized by both Olivier<sup>99</sup> and Bennet<sup>10</sup> following surgical releases in 2000. Olivier<sup>99</sup> had ninety-one patients and Bennet<sup>10</sup> had sixty-eight patients who reached statistically significant ( $p < 0.05$ ) gains in range of motion and function after a capsulotomy and post op use of CPM. Aldridge<sup>4</sup> compared the efficacy of CPM to a traditional splinting program in 2004. Splinting programs following a surgical release of a stiff joint had been the standard of practice with many surgeons. This study of 106 joints joins the growing body of research demonstrating statistical superior results of CPM ( $p = 0.27$ ) over splint and physical therapy only programs.

Nicholson<sup>85</sup> found that CPM following an arthroscopic release in the shoulder was equally effective across five identified etiologic groups as well as providing pain relief in 2003. Recent studies by

Bae & Waters<sup>8</sup> in 2001, Tsionos<sup>135</sup> in 2004, and Wu<sup>143</sup> in 2003 confirm that CPM following a joint release to the shoulder, elbow or hand is needed to reach functional range of motion.

The average period of use was six weeks following a surgical release or manipulation of the shoulder, elbow or hand in order to reach statistically significant improvements in range of motion and function. Only one author out of sixteen mentioned that they used CPM for 4 weeks. Actual duration depended on the patient. If the patients range of motion stabilized (no increase or decrease) then CPM was reduced or discontinued. If a loss of motion was detected or continued gains seen then CPM was continued.

### Surgical Release, Manipulation Under Anesthesia, Contracture/Stiffness<sup>4,8,10,12,13,35,41,52,60,85,99,100,126,135,143</sup>

#### SET-UP

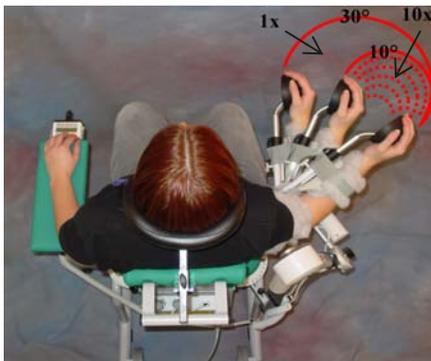
- The patient is fitted and instructed on use of the Kinex Shoulder CPM Device (preoperatively if possible to improve compliance).<sup>60,128</sup>
  - ⇒ **Repeatable Anatomical Position:** Kinex Head Positioner is aligned to the patient to ensure correct positioning each time the CPM device is used.
  - ⇒ **Anatomical Shoulder Alignment:** Kinex Multi-plane Adjustable Arm helps ensure the CPM device is aligned with the shoulder throughout the arc-of-motion.
  - ⇒ **Postsurgical Grade Computer Sensor:** Kinex extra-sensitive sensor will reverse direction of movement if too much strain is detected; set between levels 20 (light) & 25 (heavy) depending on extremity size.
- CPM use is initiated 24-48 hours postoperatively, if possible.<sup>5,13,35,60,85,143</sup>
- The Kinex Shoulder CPM Device is positioned in **scapular elevation**, abduction or flexion.
  - ⇒ Scapular elevation, abduction or forward flexion is started above 30° and increased to operative range or tolerance level.
  - ⇒ Rotation is set at operative range or tolerance level.<sup>53,60,128</sup>
  - ⇒ External rotation should be at 30° before scapular elevation, abduction or forward flexion, is beyond 90° to avoid impingement.<sup>53,128</sup>
- **Synchronized Kinex CPM:** Scapular elevation, abduction or forward flexion is synchronized with internal/external rota-

tion (internal rotation is avoided if there was a concomitant rotator cuff repair).

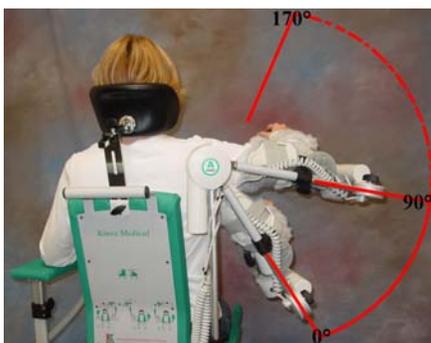
- **Isolated Kinex CPM: Scapular elevation**, abduction or forward flexion is not synchronized with rotation. Kinex Shoulder CPM ISO Mode performs **scapular elevation**, abduction or forward flexion separately from rotation (10:10 ratio). **Scapular elevation**, abduction or forward flexion is performed with external rotation at 30° or above. Rotation is performed anywhere in the elevation cycle (usually at the high end).

**WEARING SCHEDULE GUIDELINE**

- The Kinex CPM Device is used for 6-8 weeks or as needed.<sup>8,34,41,60,135</sup>
- Week one, CPM is used 6-20 hours per day or as needed.<sup>58</sup>
- Week two and beyond, the CPM is used for 4-8 hours per day in 3-4 sessions or as directed.<sup>60,128</sup>
- **Kinex End-Range-Repeat Mode:** Three hour daily use schedules or severe contractures are usually performed in the Kinex End-Rang-Repeat Mode; Last 10° of the ROM arc is repeated 10X followed by 1 complete ROM arc (10:1 ratio) in order to maximize functional use or need.

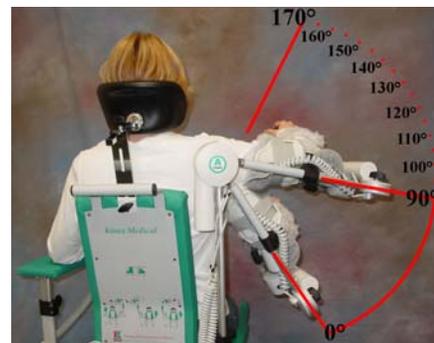


- **Kinex Static-Progressive-Stretch Mode:** This mode is used to gain motion in a contracted joint, usually not postoperatively. The Kinex CPM device is placed at end-range with the pause mode set at 5 minutes. After 5 minutes the CPM device



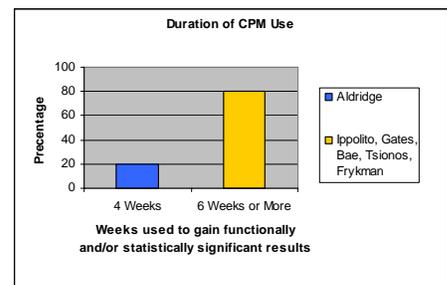
is increased to the new end-range. This continues 1-2X a day for 30-60 minutes, week one. Week two the duration is increased to 2-3X a day. Week 3 and beyond the sessions are 60-90 minutes 3X a day.

- **Kinex Dynamic-Stretch Mode:** This mode is used to gain motion in a contracted joint, usually not postoperatively. The Kinex CPM device is set at end-range. The force reversal is set between levels 15 (low) and 25 (high) depending on the extremity size or stiffness. The device will move through one full cycle followed by 10 stretch cycles (1:10 ratio). In the stretch cycle the Kinex device will attempt to move the joint 5° beyond end-range. The device will automatically reverse if a force that is stronger than the setting force is met. Duration is 1-2X for 30-60 minutes a day, week one. Week two the device is used 30-60 minutes a day for 2-3X. Week 3 and beyond the device is used 60-90 minutes a day 3X a day.



**PROM GOALS**

- The patient increases ROM as tolerated to meet ROM goals.<sup>53,60,128</sup>
- CPM use should continue if PROM goals have not been met.<sup>60</sup>
- Kinex CPM device can be set at dynamic-progressive-stretch or static-progressive-stretch mode if patient is not progressing as expected.
- Full joint motion may be less during the first 2-3 weeks post-operatively due to swelling.<sup>60</sup>
- Scapular elevation, abduction, flexion and rotation end range goal is 85% or better of the operative range.<sup>60</sup>



Note: This device must be used under the advice and care of a physician.

# Peer-Reviewed Studies Evaluating Outcome Measures for the Efficacy of CPM Following the Surgical Release of a Joint (Shoulder, Elbow, Hand)

Clinical Study	Purpose of Study	Duration of Use	Results	Primary Finding
<b>Anterior Release of the Elbow for Extension Loss: Aldridge et al (2004, J Bone Jt Surg)</b>	Compared the efficacy of CPM to splinting only following the surgical release of 106 elbow joints	CPM was used 4 weeks or longer depending on the severity of the contracture.	The total arc of motion increased 45° in the CPM group & only 26° in the splinting only group. This difference is statistically significant, p=0.27.	CPM following a surgical release offers a statistically superior (p=0.27) functional outcome over splinting alone & physical therapy.
<b>Resection of Elbow Ossification and Continuous Passive Motion in Postcomatose Patients: Ippolito et al (1999, J Hand Surg)</b>	Heterotopic periarticular ossifications were surgically excised in 16 elbow joints of traumatic brain injury patients.	The CPM was used for 6 weeks before starting a fully active rehabilitation program.	ROM improvements were greater than five previous investigators with a similar series of patients without CPM.	CPM is more effective in reaching functional range of motion after 6 weeks than physical therapy alone following a surgical release.
<b>Anterior Capsulotomy and Continuous Passive Motion in the Treatment of Posttraumatic Flexion Contracture of the Elbow; A Prospective Study: Gates et al (1992, J Bone Jt Surg)</b>	Thirty-three patients who had a post-traumatic flexion contracture of the elbow underwent an anterior capsulotomy. Fifteen patients did not receive CPM & eighteen patients did receive CPM postoperatively.	CPM was used for a mean of 6 weeks.	The mean postoperative arc of motion improved 25° in the physical therapy group and 47° in the CPM group. The difference was statistically significant.	CPM following the release of a flexion contracture resulted in a statistically significant improvement in function compared to the non-CPM group.
<b>Grading of Functional Results of Elbow Joint Arthrolysis after Fracture Treatment: Olivier et al (2000, Arch Orthop Trauma Surg.)</b>	Ninety-one patients were treated with arthrolysis for a posttraumatic contracture followed by the use of CPM.	Not Reported	The mean ROM improved from 49° to 94° in flexion and 89° to 129° in pronation/supination. The results were statistically significant at p<0.05.	The importance of an intensive early CPM program is emphasized as the results were statistically significant.
<b>Posttraumatic Contracture of the Elbow Treated with Intraarticular Techniques: Wu (2003, Arch Ortho Trauma Surg)</b>	Twenty consecutive adult patients underwent an anteroposterior capsule release. Immediately postoperatively, CPM was initiated.	Not Reported	The flexion contracture improved from a mean of 42° to 13°, flexion improved from 89° to 131°, & the total arc improved from 47° to 118°. All improvements were statistically significant at p<0.001.	A statistically significant improvement (p<0.001) in functional ROM was seen due to the use of CPM post release.
<b>Surgical Treatment of Posttraumatic Elbow Contracture in Adolescents: Bae &amp; Waters (2001, J Ped Ortho)</b>	Thirteen adolescents with posttraumatic elbow contractures were treated with open surgical release followed by CPM.	CPM was used for 6 weeks postoperatively	Avg. loss of extension improved from 57° to 15°, avg. flexion improved from 109° to 123° & total arc improved from 53° to 107°.	Open surgical release followed by the use of CPM for 6 weeks resulted in a significant improvement in functional ROM (>100°) in adolescents.
<b>Arthroscopic Treatment of Arthrofibrosis of the Elbow Joint: Phillips &amp; Strasburger (1998, J Arthro Rel Surg)</b>	Twenty-five patients with arthrofibrosis were treated with arthroscopic debridement and CPM postoperatively.	Not Reported	At an average follow up of 18 months all patients had a statistically significant (p=0.001) increase in ROM and decreased pain.	Arthroscopic release followed by CPM use obtained improvements equal to open techniques with CPM use.
<b>Arthrolysis of Posttraumatic Stiff Elbow; Which Factors Influence the End Result: Breitfus et al (1991, Unfallchirurg)</b>	A retrospective study of 59 patients who received an arthrolysis for posttraumatic stiffness. CPM was compared to splinting and physical therapy. CPM start times were also evaluated.	Not Reported	Patients started on CPM day one lost 15% of intraoperative function while those delayed to day five lost 30%. The combined PT and CPM group lost 17% compared to the splinting group which lost 35%. The CPM gains were statistically significant.	Statistically superior results were obtained with CPM compared to a splinting program. CPM started within 48 hours did better than when CPM was started day 5. Even delayed CPM use was superior to non-CPM protocols.
<b>Factors Influencing Elbow Arthrolysis: Schindler et al (1991, Ann Chir Maine Super)</b>	Retrospective study between 1982 & 1988 which evaluated the use of CPM following an arthrolysis procedure.	Not Reported	All of the improvements were statistically significant, p<0.0001. 88.2% of CPM users improved beyond 10° vs. only 28.6% for non-CPM users, while 64.7% of patients in the CPM group reached normal extension only 14.3% did in the non-CPM group (p=0.03).	The only variable of value was the use of CPM following surgery. The CPM mean improvement (32.60) was statistically superior than the non-CPM group (12.80), p<0.01.
<b>Heterotopic Ossification of the Elbow in Patients with Burns: Results after early Excision: Tsionos et al (2004, J Bone Jt Surg Br)</b>	Between 1992 & 2001, 35 elbows underwent a surgical release due to heterotopic ossification. CPM began on the 2nd postoperative day.	CPM was used for 5-8 weeks.	The gains were statistically significant from a mean of 22° to 123° in flexion/extension & 94° to 160° in pronation/supination.	A 100° arc is considered to be functional. The authors conclude that CPM is needed following a release to reach functional ROM.
<b>Arthroscopic Treatment for Adhesive Capsulitis. Bradley (1991, Operative Techniques in Orthopaedics)</b>	The initial report describes the use of CPM following arthroscopy and manipulation for primary adhesive capsulitis of the shoulder.	Not Reported	CPM is used 10 hours per day with positive results.	This preliminary study demonstrated the safety of shoulder CPM with positive results following manipulation under anesthesia for adhesive capsulitis.
<b>Addressing Glenohumeral Stiffness while Treating the Painful and Stiff Shoulder Arthroscopically: Bennet (2000, J Arthrosc Rel Surg)</b>	Thirty-one patients received either a partial or complete capsular release of the shoulder followed by CPM for passive motion therapy.	Not Reported	Thirty of thirty-one patients had a statistically significant increase in ROM (p>.05).	CPM use was a primary factor in the statistically significant results achieved.
<b>Arthroscopic Capsular Release for Stiff Shoulders Effect of Etiology on Outcomes: Nicholson (2003, J Arthrosc Rel Surg)</b>	Prospective study evaluated outcomes in 68 stiff shoulders following arthroscopic capsular release followed by the use of CPM postoperatively.	Not Reported	The study population showed a significant improvement, p<0.001. Mean improvement in ASES score was 35.5 to 93. Flexion improved from 92° to 165° & Ext. Rot. Improved from 12° to 56°.	Arthroscopic shoulder capsular release with postoperative CPM was as equally effective across 5 identified etiologic groups and provided pain relief, restoration of motion and function within an average of 3 months.
<b>CPM Improves Range of Motion after PIP and MP Capsulectomies; A Controlled Prospective Study: Frykman et al (1989, American Society for the Surgery of the Hand, 44th annual meeting)</b>	A controlled prospective study that evaluated the use of CPM after capsulectomy of the MP and PIP joints for posttraumatic ankylosis. All had failed to improve from a vigorous hand therapy program and several had failed a previous capsulectomy procedure with no CPM postop.	CPM was used on average for 6 weeks after surgery.	Both groups received the same postoperative hand therapy program with CPM the only difference between groups. The CPM group had statistically superior gains in ROM (p<.05) over the non-CPM group with less pain.	The CPM group following a MP or PIP capsulectomy had a statistically significant (p<.05) gain in PROM & AROM in contrast to the conventional hand therapy program only.



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