Peer-Reviewed Studies Evaluating Outcome Measures for the Efficacy of Elbow CPM Following Surgical Release, and Stable Fracture

Clinical Study	Purpose of Study	Duration of Use	Results	Primary Finding
Anterior Release of the Elbow for Extension Loss: Aldridge et al (2004, J Bone Jt Surg)	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.**
Resection of Elbow Ossification and Continuous Passive Motion in Post-comatose Patients: Ippolito et al (1999, J Hand Surg)	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 then five previous investigators with a similar series of patients without CPM.	**CPM is more effective in reaching functional range of motion after 6 weeks then physical therapy alone following a surgical release.**
Anterior Capsulotomy and Continuous Passive Motion in the Treatment of Post-traumatic Flexion Contracture of the Elbow; A Prospective Study: Gates et al (1992, J Bone Jt Surg)	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 post-operatively.	CPM was used for a mean of 6 weeks.	The mean post-operative 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.**
Grading of Functional Results of Elbow Joint Arthrolysis after Fracture Treatment: Olivier et al (2000, Arch Orthop Trauma Surg)	Ninety-one patients were treated with arthrolysis for a post-traumatic 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.**
Post-traumatic Contracture of the Elbow Treated with Intraarticular Techniques: Wu (2003, Arch Ortho Trauma Surg)	Twenty consecutive adult patients underwent an anteroposterior capsule release. Immediately post-operatively, 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 do to the use of CPM post-release.**
Surgical Treatment of Post-traumatic Elbow Contracture in Adolescents: Bae & Waters (2001, J Ped Ortho)	Thirteen adolescents with post-traumatic elbow contractures were treated with open surgical release followed by CPM.	CPM was used for 6 weeks post-operatively.	Average loss of extension improved from 57° to 15°, average 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.**
Arthroscopic Treatment of Arthrofibrosis of the Elbow Joint: Phillips & Strasburger (1998, J Arthro Rel Surg)	Twenty-five patients with arthrofibrosis were treated with arthroscopic debridement and CPM post-operatively.	Not Reported	At an average follow up of eighteen months all patients had a statistically significant (p=0.001) increase in ROM and decreased pain.	**Arthroscopic release followed by CPM obtained statistically significant results.**
Arthrolysis of Post-traumatic Stiff Elbow; Which Factors Influence the End Result: Breitfus et al (1991, Unfallchivrg)	A retrospective study of 59 patients who received an arthrolysis for post-traumatic stiffness. CPM was compared to splinting and physical therapy. CPM start times were also evaluated.	Not Reported	Patients who 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 then CPM started day five. Even delayed CPM use was superior to non-CPM protocols.**
Factors Influencing Elbow Arthrolysis: Schindler et al(1991, Ann Chir Maine Super)	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 (32.6°) was statistically superior then the non-CPM group (12.8°), p<0.01.**
Heterotopic Ossification of the Elbow in Patients with Burns; Results after early Excision: Tsionos et al (2004, J Bone Jt Surg Br)	Between 1992 & 2001, 35 elbows underwent a surgical release do to heterotopic ossification. CPM began on the second post-operative 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.**
Elbow Flexion Contractures: Treatment by Anterior Release and Continuous Passive Motion: Breen et al (1987, J Hand Surg)	Patients with post-traumatic flexion contractures who did not respond to non-operative physical therapy, dynamic splinting or bracing were treated by anterior surgical release and post-operative CPM.	CPM was started in the hospital and continued in the patient's home.	There were no complications and the patients tolerated CPM well. The mean flexion contracture was 41° and the mean improvement was 36°, leaving a mean flexion contracture of 5°.	**The authors compared their series to a similar series by Urbaniak (1985, JBJS) who did not use CPM post-operatively (splinting only) that resulted in an average of a 19º contracture. The author's states that their improved outcomes are do to the post-operative use of CPM.**

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Debridement Arthroplasty for Osteoarthritis of the Elbow: 50 patients followed a Mean of 5 Years: Oka (2000, Acta Orthop Scand)	Their were 26 athletes and 24 laborers who underwent debridement arthroplasty for contractures do to osteoarthritis.	CPM was initiated at 5 days post-operatively.	The patients were evaluated after 5 years and exhibited a mean improvement of 24°. There was no difference in improvement between athletes and laborers.	**The authors conclude that debridement arthroplasty followed by CPM is an effective treatment in athletes and laborers with osteoarthritis of the elbow.**
The Lateral Approach for Operative Release of Posttraumatic Contracture of the Elbow: Husband et al (1990, JBJS)	A lateral release was used in this series of patients with a post-traumatic elbow contracture followed by the use of CPM post-operatively.	CPM was initiated immediately post-operatively.	The patients were evaluated an average of 38 months post-operatively. The mean arc of motion improved 46°.	**A lateral release is an effective surgical option following an elbow contracture when CPM is used post-operatively.**
Arthrolysis of the Elbow in Post-traumatic Contracture: Blauth et al (1990, Orthopade)	In a retrospective study, 125 out of 168 patients were reviewed following an arthrolysis and application of CPM for post-traumatic stiffness.	Not Reported	In 77% of patients, the results were very good, good or satisfactory. Overall, the mean increase was 49° or a 58% improvement.	**Arthrolysis followed by CPM demonstrated significant improvements in 125 patients who were reviewed by the author.**
The Bryan-Morrey Triceps-Sparing Approach to Open Reduction of T-Condylar Humeral Fractures in Adolescents: Cybex Evaluation of Triceps Function and Elbow Motion: Remia et al (2004, J Ped Ortho)	A series of patients underwent open reduction of a T-condylar distal humerus fracture followed by early use of CPM.	Not Reported	The average follow up was 3 years and 5 months. The average range of motion was -8° to 136°. These results were statistically significant.	**In this series, early post-operative CPM was found to significantly increase range of motion.**
T-Condylar Fractures of the Distal Humerus in Children and Adolescents: Re et al (1999, J Ped Orthop)	This was a retrospective review of 17 T-condylar fractures in children and adolescents. It examined the results by sex, age, arm injured, hand dominance, mechanism of injury, operative procedure, CPM use, and outcome.	Not Reported	Improvements contributed to the use of CPM were statistically significant at $p<0.05$.	**"The use of CPM in the immediate post-operative period resulted in a functional range of motion sooner and yielded a statistically significant increase in flexion at follow up exam compared to the group without CPM" ($p<0.05$).**
Intraarticular Fractures of the Distal Humerus, Surgical Treatment and Results: Letsch et al (1989, Clin Ortho Rel Res)	This preliminary study evaluated 104 patients who underwent a surgical repair of the distal humerus over a 12 year period. CPM was used immediately in the hospital and part of the home program. Outcome measures included ROM, pain, and working capacity.	Not Reported	The long term outcomes (81%) were rated as very good or good do to the surgical treatment and the post-operative use of CPM.	**The use of CPM post-operatively contributed to a 30% reduction in hospitalization time because home therapy was improved. The authors also report that the use of CPM decreased the incidence of myositis ossificans.**
Continuous Passive Motion after Internal Fixation of the Distal Humerus: Soffer et al (1990, Ortho Rev)	This small series preliminary study evaluated the use of CPM following stabilization of distal humerus fractures.	Not Reported	All patients recovered full pronation/supination and functional ROM in flexion/ extension.	**The authors concluded in this early study that CPM was a valuable therapeutic modality in the post-operative management of intra-articular fractures of the elbow.**
Tuberculous Arthritis of the Elbow: Chen et al (1998, International Orthopaedics)	Twenty-three patients with tuberculous arthiritis of the elbow were treated including the use of CPM post-operatively and followed for 3 to 8 years	Not Reported	Early diagnosis and surgical treatment resulted in good functional outcomes when CPM is included in post-operative care.	**"Post-operative CPM is valuable in improving range of movement in elbows with extensive osteoarticular tuberculosis."**
Progressive Surgical Release of a Post-traumatic Stiff Elbow, Techniques and outcome after 2-18 years in 46 patients: Marti et al (2002, Acta Orthop Scand)	This study evaluated surgical techniques and post-operative rehabilitation on 46 patients suffering from post-traumatic contracture of the elbow joint. Rehabilitation outcomes were evaluated at a mean of 10 years.	CPM was utilized immediately post-operatively.	Mean post-operative flexion was 114° and the mean extension lag was 5°. Pronation/Supination improved from a mean of 8° to a mean of 98°.	**The results of our rehabilitation program support the findings of Gates et al (1992) that post-operative use of CPM improves total range of motion and therefore function.**

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