Clinical Guidelines for Phase I Rehabilitation following Knee Articular Cartilage Procedures

The primary goal of post-surgical rehabilitation following cartilage repair (microfracture, grafting, autologus chondrocyte transplantation) is to control pain, reduce inflammation, protect the repaired tissue during the healing process, restore function, improve range-of-motion, and accelerate soft tissue healing. During the initial healing phase following surgery, six to eight weeks[4,11,16,25] or more of passive range of motion is performed to protect the integrity of the repair.[3] For a growing number of surgeons continuous passive motion (CPM) has become the Gold Standard for passive motion therapy during phase one of the rehabilitation program.[3,5,12,15,22,23,25]

Anti-Inflammatory

O'Driscoll and Giori[13] have demonstrated that CPM immediately following a surgical procedure 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. Salter[18-22], Kim[5], Kroeder[6] and Moran[12] 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[2], Lee[8], Xu[33] and Ferretti[1] have helped explain the molecular basis for the beneficial effects of CPM on the inflamed joint. A CPM device by safely applying cyclic tensile stress on the involved joint for an extended time counteracts the effects of the inflammatory agents even better than immobilization.

Microfracture

Rodrigo J, Steadman R, Sillman J, and Fulstone H: Improvement of Full-Thickness Chondral Defect Healing in the Human Knee After Debridement and Microfracture and Using Continuous Passive Motion. Am J Knee Surg 7(3), Summer 1994.

"Since 1985, 298 patients have been studied after treatment of full-thickness articular surface defects of the knee. Most of these defects were found at the time of arthroscopy for other soft tissue injuries, and all were treated with a debridement and of the exposed subchondral bone. The lesions were graded from 1-5 at the initial and also at *second look* (77 patients), with Grade 5 being a chronic *bare-bone* lesion, and Grade 1 being normal appearing cartilage (all but 1 patient scored 5 initially). Although CPM was recommended for 8 weeks post-operatively for all patients, only forty-six of the sample of seventy-seven were able to comply, primarily because of insurance restrictions. We compared the two resulting subgroups: Group 1, with CPM (N=46) and Group 2, without CPM (N=31). The mean improvement in grade for patients in Group 1 was 2.67 as compared to 1.67 for Group 2 (p=.003). Only 15% of Group 1 had no improvement in Grade, whereas 45% of Group 2 had no improvement (p=.0065). The improvement in Group 1 over Group 2 was the same whether or not the lesion was patella-femoral or tibial-femoral, large or small, or in a young individual or older individual. We conclude that CPM for six hours daily for eight weeks post debridement and microfracture for full-thickness cartilage defects in the knee results in better gross healing of the lesion when evaluated by arthroscopic visualization as compared to the same treatment without CPM."

Autologous Periosteal Transplantation

Alfredson H, Lorentzon R: Superior Results with Continuous Passive Motion Compared to Active Motion after Periosteal Transplantation: A retrospective study of human patella cartilage defect treatment. *Knee Surg Sports Traumatol Arthrose* 7 (4): 232-8, 1999.

Fifty-seven consecutive patients, with a mean age of 32 years (range 16-53 years), who suffered from an isolated full-thickness cartilage defect of the patella and disabling knee pain of long duration, were treated by autologous periosteal transplantation to the cartilage defect. The first 38 consecutive patients (group A) were postoperatively treated with continuous passive motion (CPM), and the next 19 consecutive patients (group B) were treated with active motion for the first 5 days postoperatively. In both groups the initial regimens were followed by active motion, slowly progressive strength training, and slowly progressive weight bearing. In group A, after a mean follow-up of 51 months (range 33-92 months), 29 patients (76%) were graded as excellent or good, 7 patients (19%) were graded as fair, and 2 patients (5%) were graded as poor. In group B,

after a mean follow-up of 21 months (range 14-28 months), 10 patients (53%) were graded as excellent or good, 6 patients (32%) were graded as fair, and 3 patients (15%) were graded as poor. Altogether, nine of the fair or poor cases (50%) were diagnosed with chondromalacia of the patella. Our results, after performing autologous periosteal transplantation in patients with full-thickness cartilage defects of the patella and disabling knee pain, are good if CPM is used postoperatively. The clinical results using active motion postoperatively are not acceptable, especially not in patients with chondromalacia of the patella.

Autologous Chondrocyte Transplantation

Minas T, Peterson L: Chondrocyte transplantation. Operative Techniques in Orthopaedics 7(4), 1997.

Autologous chondrocyte transplantation (ACT) provides a durable hyaline repair tissue in correctly selected indications. Autologous chondrocyte transplantation is indicated for full-thickness, weight-bearing condyle injuries and injuries to the trochlea of the femur. ACT results in reproducibly satisfactory results with return to high-level activities including sports in over 90% of the patients. Second-look arthroscopies demonstrate tissue fills with biopsies showing hyaline-like cartilage repair. Hyaline cartilage repair is critical because this has been shown clinically to give long standing results with follow-up at to 9 years. As technical refinements improve and rehabilitation protocols, results for injuries to the patellar and the tibia will improve at this time the response to treating bipolar focal chondral injuries is unknown and not recommended. Continuous Passive Motion (CPM) is instituted as soon as cell attachment has occurred after 6 hours or the next day. CPM is increased to regain full range of motion to the patient's tolerance with a very slow cycle setting of approximately 2 minutes. CPM is used for approximately 6 to 8 hours daily for up to 6 weeks postoperatively. This is based on experimental work showing an enhanced quality of repair tissue caused by this modality as well as clinical work showing an increase in repair tissue fill with use of CPM 6 to 8 hours per day for 6 to 8 weeks postoperatively.

Proximal Tibial Valgus Osteotomy

Schultz W, Göbel D: Articular cartilage regeneration of the knee joint after proximal tibial valgus osteotomy: a prospective study of different intra- and extra-articular operative techniques. Knee Surgery, Sports Traumatology, Arthroscopy 7(1): 29-36, January 1999.

"In this prospective study high tibial osteotomy for medial gonarthrosis was performed in 95 patients (105 knee joints). A follow-up arthroscopic examination could be performed in 75 patients (85 knee joints) at the time of implant removal. In group 1 (20 knee joints), the osteotomy was performed after diagnostic arthroscopy without arthroscopic operation of the knee joint. The fixation of the osteotomy was accomplished by staples, postoperative plaster fixation and physiotherapy. In group 2 (20 knee joints), osteotomy was performed without additional operative arthroscopy after diagnostic arthroscopy, internal fixation by AOT-plate, no external fixation postoperatively and physiotherapy. In group 3 (22 knee joints), osteotomy was performed with additional operative arthroscopy (Pridie drilling), internal fixation by AOT-plate no external fixation postoperatively no external fixation, physiotherapy and continuous passive motion. In group 4 (23 knee joints), osteotomy was performed with additional operative arthroscopy (abrasio-arthroplasty), internal fixation by AOT-plate, no external fixation postoperatively, physiotherapy and continuous passive motion. All patients underwent arthroscopic examination of the knee with cartilage biopsies taken from three different regions of the femoral condyle during the same operative session as the osteotomy. At follow-up arthroscopy cartilage biopsies were taken from the same regions. There was no great difference in clinical outcome after 1 year between all groups. Arthroscopy as well as routine and electron microscopy showed better cartilage regeneration in groups 3 and 4. Groups 1 and 2 showed only regeneration isles, sometimes not well fixed to the underlying bone, while in groups 3 and 4 cartilage regeneration was thicker and more stable, sometimes covering all of the pre-existing erosions." This series found the best results when osteotomy of the tibia for osteoarthritis together with operative arthroscopy in the same operative session and the use of CPM postoperatively.

Home Exercise Compliance is Improved by the use of CPM

Milroy[10] in a review of home exercise compliance found one-third of patients can be expected to comply with their home program, another one- third will partially comply and the final one-third will not comply. In contrast, Rosen[17] reported a compliance rate as high as 122% for CPM as participants utilized the device for 7 hours on average which was higher than the 6 hour daily requested rate. High home compliance for CPM programs may be explained by the reduction in pain associated with knee CPM use.[9,20,34]

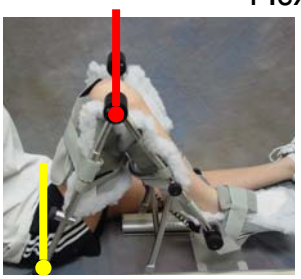
ARTICULAR CARTILAGE TREATMENT

1. Set-Up Guidelines

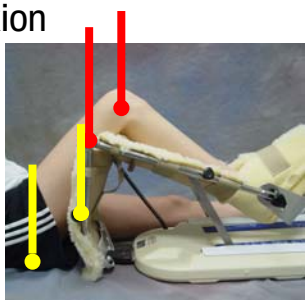
- If possible the patient should be instructed on knee CPM use preoperatively to improve compliance.[7]

⇒ Anatomical Knee Alignment: Kinex 4-Point leverage system helps ensure the CPM device is in alignment throughout the arc-of-motion. Helps avoid stress on the repair.

Flexion

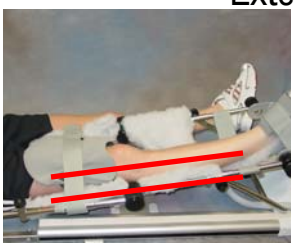


Kinex CPM with 4-points of leverage

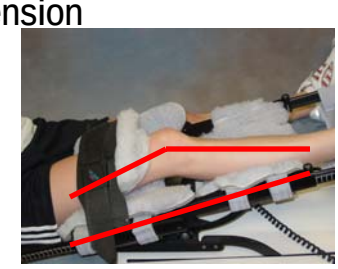


CPM without 4-points of leverage

Extension



Kinex CPM with 4-points of leverage



CPM without 4-points of leverage

Note: CPMs with a thigh bar do not always ensure knee extension because there are only 2-points of leverage.

Note: Calf is not a support point.[7]

- CPM should be initiated 6-48 hours postoperatively. [7,16,24,26,29-31]
- CPM is only used in a pain free arc of motion to protect the repair. [7]

⇒ Repeatable Anatomical Position: Kinex 4-point leverage system ensures correct positioning each time the knee CPM is used. Helps avoid repair stress.

Wearing Schedule Guidelines:

- The Kinex CPM is used for 6-8 weeks.
- Kinex CPM is used 6-8 hours per day.

- Initial ROM Setting:
  - ⇒ The Kinex Knee CPM is supported at the heel and thigh with no support at the calf.[14]
  - ⇒ Extension: 0° or as tolerated in a pain free arc
  - ⇒ Flexion: 30° or as tolerated in a pain free arc

2. Wearing Schedule

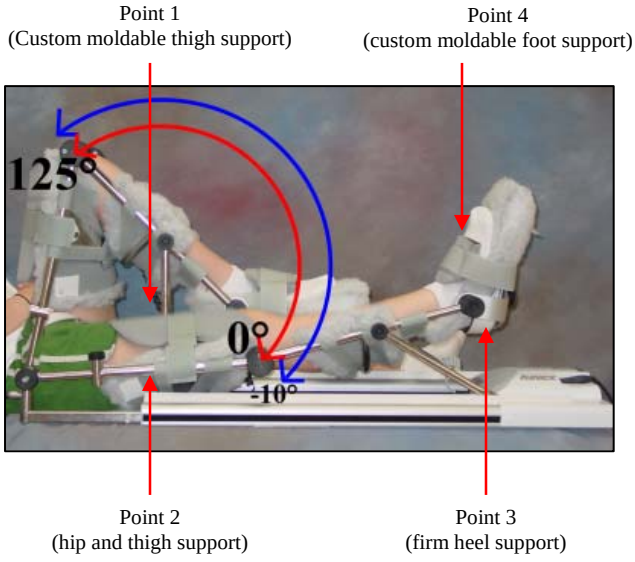
- Microfracture technique: The CPM is used for 8 weeks. [16,25-27]
- Articular cartilage grafting: The CPM is used for 6 weeks. [14,16,24,26,28]
- Autologus chondrocyte transplantation: The CPM is used for 6-8 weeks.[14,16,24,26]
  - ⇒ The CPM device is worn 6-8 hours a day.[14,16,24,26,27,32]
  - ⇒ The patient increases PROM 5-10° a day as tolerated in a pain free arch.

3. End-Range Goals:

- ⇒ Flexion 125°
- ⇒ Extension/Hyperextension 0° to minus 5°

  Note: Specific PROM parameters are determined by the physician.

- Kinex ISO™ Mode: Extension force reversal setting is separate from flexion force reversal setting. Knee extension is set between 10-20 (low resistance) and extension ROM is set at 0°. The CPM will work toward 0° extension without the patient changing the ROM parameters. If too much resistance is detected the Kinex device will automatically reverse direction.



CONTRAINDICATIONS
Acute inflammation of the joints, unless explicitly recommended by the doctor, spastic paralysis, unstable fractures. *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 Cartilage Repair

Clinical Study	*Purpose of Study*	*Duration of Use*	*Results*	*Primary Finding*
The Physiologic Basis of Continuous Passive Motion for Articular Cartilage Healing and Regeneration: Salter B (1994, Hand Clinics)	An overview of the author's first 23 years of experience with basic research relevant to the biological concept of continuous passive motion (CPM) of synovial joints in vivo, as well as the first 15 years of experience with clinical application of CPM.	Six to eight hours of use per day appears to offer the best benefits. This summary of studies did not report duration of CPM as part of the summary.	Basic research demonstrated the safety of CPM and benefits that included: regeneration of hyaline cartilage, improved fracture healing, improved motion, anti-inflammatory effects, & thicker/stronger tendon healing. Clinical benefits include: decreased pain, increased motion, high compliance, faster wound healing, no complications and reduced rehabilitation.	This summary of extensive research has led to the following accepted uses of CPM following: stable fractures, arthrotomy, capsulotomy, arthrolysis, synovectomy, biological resurfacing, acute ligament repair, tendon graft for ligament repair, tendon repair, osteotomy and prosthetic joint replacement.
Effects of Continuous Passive Motion and Immobilization on Synovitis and Cartilage Degradation in Antigen Induced Arthritis: Kim et al (1995, J Rheumatol)	To determine the effects of continuous passive motion and immobilization on synovitis and cartilage degradation in an experimental model of chronic inflammatory, antigen-induced arthritis.	Not applicable	The articular cartilage degradation was significantly greater in the immobilized knees compared to its opposite CPM treated knees. Five of 12 immobilized knees had articular surface erosion compared to none in the CPM treated knees. Loss of cellularity was also significantly greater in the immobilized knees.	Articular cartilage was better preserved in the knees treated with CPM than immobilization at six weeks.
Experimental Study on the Repair of Full Thickness Articular Cartilage Defects; Effects of Varying Periods of Continuous Passive Motion, Cage Activity, and Immobilization: Shimizu et al (1987, J Orthop Res)	In order to clarify the dose/response characteristics of CPM, the repair process of full thickness articular cartilage defects was studied in a rabbit model. The following CPM combinations & immobilization (immob) were tested: CPM 24 h/day, CPM 8/hr-immob 16/h, CPM 2/h-immob 22/h, and immob 24 h/day.	Not applicable	The CPM 24 h/day & CPM 8 h/day groups demonstrated better repair than the other groups with more chondrocytes in the repair tissue. The CPM 2 h/day group only showed slightly better repair than the immob group. CPM following initial mobilization was not able to overcome the harmful effect of immobilization.	The authors conclude that CPM for 8 or 24 h/day is effective for adequate cartilage repair even with some immobilization. CPM application should be 8 hours a day. If CPM is delayed for a week following immobilization, the effect of CPM on cartilage will be reduced.
Biological Resurfacing of Full-Thickness Defects in Patellar Articular Cartilage of the Rabbit; Investigation of Autogenous Perisoteal Grafts Subjected to Continuous Passive Motion: Moran et al (1992, J Bone Jt Surg Br)	The authors compared CPM with intermittent active motion on the results of the resurfacing with autogenous periosteal grafts of full-thickness defects.	Not applicable	The quality of nechondrogenesis was statistically superior in the CPM group ($p<0.05$) compared to the intermittent group.	The addition of CPM after surgery was shown to improve every aspect of healing and resurfacing of the defect.
Outcomes of Microfracture for Traumatic Chondral Defects of the Knee; Average 11-year Follow-up: Steadman et al (2003, Arthrscopy)	Patients were treated with microfracture for chondral defects and a post-operative regimen of CPM or 8 weeks. At final follow-up all patients were evaluated with Tegner, Lysholm, WOMAC, and the modified SF-36.	CPM was used for 8 weeks.	At follow-up, all parameters indicated significant improvement. Most of the improvement occurred in the first year with continued improvement up to 3 years.	The authors stress that rehabilitation consisting of protected weight-bearing and CPM for 8 weeks is an essential component to achieve 90% good results with the microfracture procedure.
Autologous Chondrocyte Transplantation for Reconstruction of Isolated Joint Defects; the Assaf Harofeh: Robinson et al (2000, IMAJ)	Biopsies were obtained from patients aged 18-45 who underwent autologous chondrocyte transplantation followed by CPM for passive motion. Follow-up was 6 months to one year.	Not reported.	MRI studies in all patients revealed that the defects were filled with tissue having similar signal characteristics to cartilage.	Chondrocyte implantation followed by CPM is a procedure capable of restoring normal articular cartilage in cases with isolated joint defects. Pain can be predictably reduced, while joint locking and effusion eliminated.

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