

MACI[®] (autologous cultured chondrocytes on porcine collagen membrane)

REHABILITATION MANUAL



autologous cultured
chondrocytes
on porcine
collagen membrane

Please see accompanying Important Safety Information and full Prescribing Information.



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OVERVIEW AND PURPOSE

INTRODUCTION

The purpose of this manual is to provide guidance for the development of a physician-prescribed rehabilitation program that fosters early mobilization and load protection to promote graft maturation and reduce the risk of graft delamination, post-operative thromboembolic events and joint stiffness. *The MACI® (autologous cultured chondrocytes on porcine collagen membrane) Rehabilitation Manual Guidelines* are based on clinical experience* that supports the use of a controlled rehabilitation program to promote a progressive return to full range of motion and weight bearing as well as muscle strengthening and conditioning.

The rehabilitation program was designed using knowledge of basic science, anatomy and biomechanics of articular cartilage, as well as the natural course of healing following implantation, and is not intended as a substitute for individual clinical judgment. The goal is to restore optimal function in each patient as quickly and safely as possible.

KEY POINTS OF CONSIDERATION

- **Patient adherence** to the prescribed rehabilitation program is important and deviation from the program may compromise the clinical benefit of the MACI implant
- **Lesion size, location and patient characteristics** are significant factors in determining a rehabilitation program for each patient
- **Although timeframes have been established as a guide**, it is more important that goals are reached at the end of each phase prior to progression to the next
- **It is important to avoid excessive load/weight bearing** on the graft site to allow proper healing. Take note of specific precautions mentioned in this guide. Information regarding the location, size, and specifics of the implantation site should be obtained from the surgeon
- **Pain and swelling must be carefully monitored** throughout the rehabilitation process. If either occurs in excess to what is routinely seen, the ensuing activity needs to be identified and appropriately adjusted to lessen the irritation. Ice packs may be used to control swelling. Ignoring these symptoms may compromise the success of the surgery and the patient's outcome
- **At any time during or after the rehabilitation process**, if sharp pain with locking or swelling is experienced, the patient should notify his or her surgeon

*Ebert JR, Fallon M, Robertson WB, Lloyd DG, Zheng MH, Wood DJ, Ackland T.

MACI REHABILITATION TIMELINE: OVERVIEW

PRINCIPLES OF REHABILITATION

These pages set to lay out the importance of a gradual and progressive rehabilitation protocol. It stresses the importance of a tailored approach to each individual's rehabilitation that will protect the graft while stimulating the cells to promote optimal healing. Mechanical loading is an important regulator of chondrocyte differentiation. Key types of loading include cyclic compressive loading (enhances chondrogenesis); shear loading (increases matrix production and improves biomechanical structure); and static compression (which can be detrimental to development and repair of cartilage).

POST-OPERATIVE TIMELINE

Week 1 (Phase I)	WB Status	<ul style="list-style-type: none"> TF joint: ≤20% BW PF joint: <20% BW
	Ambulatory Aids	<ul style="list-style-type: none"> TF joint: 2 crutches used at all times PF joint: 2 crutches used at all times
	Knee ROM	<ul style="list-style-type: none"> TF joint: passive & active ROM from 0–30° PF joint: passive & active ROM from 0–20°
	Knee Bracing	<ul style="list-style-type: none"> TF joint: 0–30° PF joint: locked at full knee extension Hospital/Clinic—Phase I exercises
Weeks 2–3 (Phase II)	WB Status	<ul style="list-style-type: none"> TF joint: ≤20% BW (Week 1–2) to 30% BW (Week 3) PF joint: 20–30% BW (Week 1–2) to 50% BW (Week 3)
	Ambulatory Aids	<ul style="list-style-type: none"> TF joint: 2 crutches used at all times PF joint: 2 crutches used at all times
	Knee ROM	<ul style="list-style-type: none"> TF joint: active ROM from 0–30° (Week 2) to 0–90° (Week 3) PF joint: active ROM from 0–30° (Week 2) to 0–60° (Week 3)
	Knee Bracing	<ul style="list-style-type: none"> TF joint: 0–30° (Week 1–2) to 0–45° (Week 3) PF joint: locked at full knee extension Initial post-operative review (pain, swelling & wound) Education on appropriate WB & crutch ambulation Review home-based exercise program Hydrotherapy—Phase I–II exercises Clinic—Phase I–II exercises Remedial massage, soft tissue and patella mobilization, CPM & cryotherapy
Weeks 4–5 (Phase III)	WB Status	<ul style="list-style-type: none"> TF joint: 40% BW (Week 4) to 50% BW (Week 5) PF joint: 75% BW
	Ambulatory Aids	<ul style="list-style-type: none"> TF joint: 2 crutches used at all times PF joint: 1 crutch used at all times
	Knee ROM	<ul style="list-style-type: none"> TF joint: active ROM from 0–110° (Week 4) to 0–125° (Week 5) PF joint: active ROM from 0–90° (Week 4) to 0–120° (Week 5)
	Knee Bracing	<ul style="list-style-type: none"> TF joint: 0–60° (Week 4) to 0–90° (Week 5) PF joint: locked at full knee extension Hydrotherapy—Introduce Phase III exercises Clinic—Introduce Phase III exercises Remedial massage, soft tissue mobilization and patella mobilization CPM & cryotherapy as required

MACI REHABILITATION TIMELINE: OVERVIEW

Weeks 6–7 (Phases III–IV)	WB Status • TF joint: 60% BW (Week 6) to 80% BW (Week 7)	• PF joint: full WB
	Ambulatory Aids • TF joint: 1 crutch used at all times	• PF joint: 1 crutch as required
	Knee ROM • TF joint: active ROM from 0–125° (Week 6) to 0–135° (Week 7)	• PF joint: active ROM from 0–125° (Week 6) to 0–135° (Week 7)
	Knee Bracing • TF joint: full knee flexion • PF joint: no brace • Hydrotherapy—Introduce Phase IV exercises	• Clinic—Introduce Phase IV exercises • Remedial massage, soft tissue mobilization & patella mobilization
Weeks 8–10 (Phase IV)	WB Status • TF & PF joint: full WB as tolerated	
	Ambulatory Aids • TF & PF joint: 1 crutch as required	
	Knee ROM • TF & PF joint: full active ROM as tolerated	
Weeks 11–12 (Phase IV)	Knee Bracing • TF joint: full knee flexion • PF joint: no brace • Hydrotherapy—Phase I–IV exercises	• Clinic—Phase I–IV exercises • Commence proprioceptive/balance activities • Remedial massage, soft tissue mobilization and patella mobilization
	Weeks 11–12 (Phase IV) • Hydrotherapy—Phase I–IV exercises • Clinic/gym—Phase II–IV exercises	• Progress proprioceptive/balance activities • Introduce cycling, walking, resistance and CKC activities
3–6 Months (Phase V)	• Clinic/gym—Introduce Phase V exercises • Progress proprioceptive/balance activities	• Progress to more demanding CKC exercises, rowing ergometry & elliptical trainers
6–9 Months (Phase VI)	• Clinic/gym—Introduce Phase VI exercises • Progress proprioceptive/balance activities • Increase difficulty of OKC & CKC exercises (ie, step ups/downs, modified squats)	• Introduction of controlled mini-trampoline jogging
9–12 Months (Phase VII)	• Clinic/gym—Introduce Phase VII exercises • Progress proprioceptive/balance activities • Increase difficulty of OKC & CKC exercises (ie, lunges/squats on unstable surfaces)	• Introduction of agility drills relevant to the patient's activities • Return to competitive activities suggested after 12 months • Graded increase in stress based on maturation of chondral repair

MACI REHABILITATION MATURATION PHASES: OVERVIEW

PHASES OF POST-OPERATIVE REHABILITATION AND THE ASSOCIATED GRAFT MATURATION TIMELINE

REHABILITATION PHASES	
Maturation	Stages of repair tissue
1. Phase I: 0–1 week post-operative	Implantation and Protection (0–6 weeks)
2. Phase II: 2–3 weeks post-operative	
3. Phase III: 4–6 weeks post-operative	
4. Phase IV: 7–12 weeks post-operative	Transition and Proliferation (6–12 weeks)
5. Phase V: 3–6 months post-operative	Remodeling (12–26 weeks)
6. Phase VI: 6–9 months post-operative	
7. Phase VII: 9–12 months post-operative and return to activities	Maturation (26 weeks onward)

PHASES OF MACI REHABILITATION PLAN

PHASE I: (0–1 WEEK POST-OPERATIVE)

During the days immediately following post-operative, it is important to maintain joint mobility and muscle tone without placing undue stress on the implant area. Prior to discharge, the patient also must be proficient in and comfortable with all aspects of home exercise and functional activities.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN: PHASE I

GOALS

Maintain joint mobility and muscle tone while adhering to all post-operative precautions.

REHABILITATION PLAN

Initiate on post-operative Day 1 unless otherwise instructed by the operating surgeon.

1. Provide appropriate analgesics for pain control.
2. Commence continuous passive motion (CPM) (0–30° of knee flexion) 12–24 hours post-operative, for a minimum of 1 hour daily to reduce the chance of intra-articular adhesions¹ and potentially speed up and improve the quality of tissue repair.^{2,4}
3. Fit a post-operative range of motion (ROM) control brace (initially set at 0–30° of knee flexion); this should be worn 24 hours per day for the first 3 weeks.
4. Apply cryotherapy as standard edema control (20 minutes with ice, at least 3 times per day).
5. Perform active dorsi-flexion and plantar-flexion exercises of the ankle to encourage lower extremity circulation.
6. Encourage isometric contraction of the quadriceps, hamstrings and gluteal musculature to help maintain muscle tone and minimize muscle loss.^{5,6}
7. Oversee breathing exercises to ensure proper technique during therapeutic exercise.
8. Offer instruction and practice in proficient toe-touch ambulation (using 2 crutches, with ≤20% of body weight [BW] through the operated limb, unless otherwise indicated by the operating surgeon), and safety with bed transfers and stairs.
9. Provide detailed verbal and written instruction on how to perform activities of daily living and functional tasks, whilst adhering to post-operative precautions and appropriate weight-bearing (WB) status.

CONTRAINDICATIONS

1. Excessive load bearing (>20% of patient BW) especially in combination with knee flexion
2. Ambulation without crutches and a protective knee brace
3. Generation of shear forces within the knee
4. Knee flexion beyond 30°
5. Active knee extension (especially against resistance)

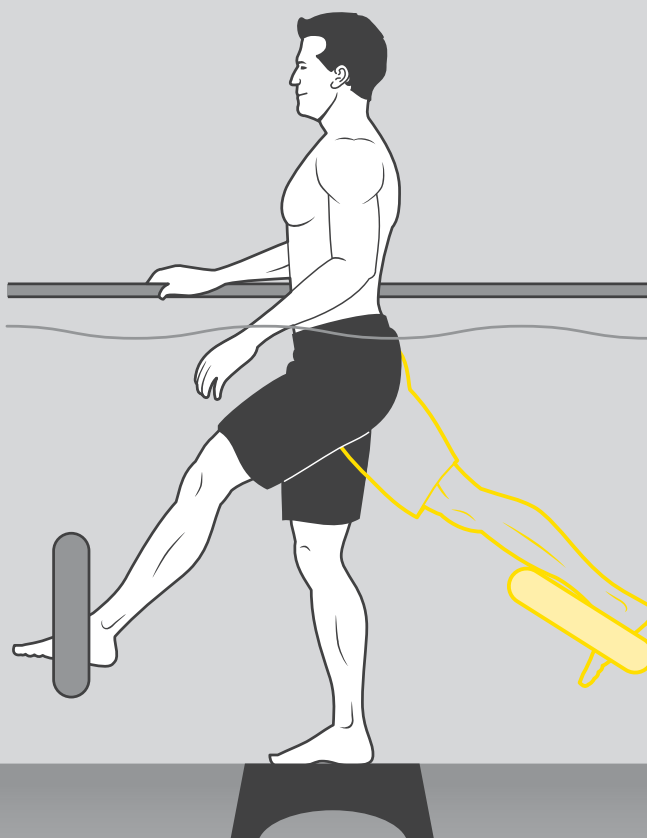
PRIOR TO DISCHARGE

1. Ensure that the patient has an initial appointment (or appropriate contacts) for out-patient functional rehabilitation.
2. Ensure that the patient is aware that the next post-operative appointment with the orthopedic surgeon normally occurs within 4–6 weeks post-operative.
3. If required, ensure that patient has an appointment for the removal of stitches/staples, or is aware when they must be removed (generally within 8–10 days post-operative).
4. Instruct and educate the patient on the importance of following the RICE (rest, ice, compression and elevation) guidelines for edema control.
5. Reinforce WB constraints and brace guidelines.
6. Review the home exercise regimen, ensuring the patient is proficient in safely performing these activities.
7. Review (and educate on) techniques for performing functional activities (eg, stairs, bed transfers, showering, etc), ensuring the patient is proficient in safely performing these activities.
8. Ensure the patient is educated in wound healing, and how to assess changes in the wound and surrounding soft tissue that may indicate infection.

PHASES OF MACI REHABILITATION PLAN

PHASE II: (WEEKS 2–3 POST-OPERATIVE)

During these first weeks, the patient should achieve pain-free and full passive knee extension, as well as limited weight bearing. Additional focus is placed on maintaining muscle tone and ensuring proper wound healing and edema control.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN: PHASE II

THE INITIAL POST-OPERATIVE SESSION

1. Review the patient's level of pain and medication use.
2. Review the patient's swelling and provide appropriate education on the RICE (rest, ice, compression and elevation) guidelines for edema control.
3. Review the patient's wound and reinforce education on wound monitoring, cleanliness and infection control.
4. Ensure the appropriate knee brace is obtained, correctly fitted and adjusted appropriately (0–30° of knee flexion, or as directed by the orthopedic specialist).
5. Ensure proficiency with crutches, both during normal ambulation and negotiating stairs.
6. Provide appropriate education, training and proficiency with the desired level of partial weight bearing (WB) ($\leq 20\%$, or as directed by the orthopedic specialist).⁷
7. Reiterate instructions and movement contraindications outlined by the orthopedic specialist and the hospital rehabilitation therapists.
8. Review and progress the home exercise program based on the current post-operative timeline and status of the patient.

GOALS

By Week 3 post-operative, patients are expected to achieve:

1. Pain-free knee flexion of 90° for tibiofemoral (TF) grafts and 60° for patellofemoral (PF) grafts.
2. Pain-free and full passive knee extension.
3. Proficient heel-to-toe gait with 30% body weight (BW) for TF grafts or 50% BW for PF grafts, using 2 crutches and a knee brace.
4. Reduced (and/or well-controlled) post-operative pain and edema.
5. Ability to generate an active, isometric quadriceps contraction.
6. Proficiency with home-exercise program.

PHASES OF MACI REHABILITATION PLAN: PHASE II

REHABILITATION PLAN

WEIGHT BEARING

Electronic scales should be used as a means to train, educate and provide practice to patients in attaining the desired levels of partial WB,^{7,8} calculated as a percentage of the patient's BW, throughout the post-operative timeline.

- TF joint: progress from $\leq 20\%$ BW (Weeks 1–2) to 30% BW (Week 3)
- PF joint: progress from 20–30% BW (Weeks 1–2) to 50% BW (Week 3)

AMBULATORY AIDS

- TF joint: 2 crutches
- PF joint: 2 crutches

RANGE OF MOTION (ROM)

- TF joint: progress active ROM from 30° (Week 2) to 90° (Week 3)
- PF joint: progress active ROM from 30° (Week 2) to 60° (Week 3)

PROTECTIVE KNEE BRACING

- TF joint: progress brace from 0–30° (Weeks 1–2) to 0–45° (Week 3)
- PF joint: lock brace at full knee extension

PHASES OF MACI REHABILITATION PLAN: PHASE II

ROM AND FLEXIBILITY EXERCISES

- Use continuous passive motion (CPM) at the end of each session for 20–30 minutes to reduce the chance of intra-articular adhesions¹ and potentially speed up and improve the quality of tissue repair²⁻⁴
- TF joint: progress from 30° (Week 2) to 90° (Week 3)
- PF joint: progress from 30° (Week 2) to 60° (Week 3)
- Passive and active heel slides
- Passive knee extension
- Careful patellar mobilization in all directions

STRENGTHENING EXERCISES

- Isometric quadriceps contraction and co-contraction activities (aided with the use of neuromuscular electrical muscle stimulation to stimulate voluntary muscular contraction)
- Isometric gluteal, hamstrings, adductor and calf contractions
- Straight-leg-raise activities (hip flexion, abduction, adduction and extension)

HYDROTHERAPY EXERCISES

- Deep-water walking (forwards, backwards and sideways)
- Deep-water calf raises
- Straight-leg hip flexion, extension, abduction and circumduction (with or without floatation devices for additional resistance)
- Passive knee flexion
- Stretching of hamstring and calf musculature

ADJUNCT MODALITIES

- Perform clearance and lymphatic remedial massage as needed to assist in the reduction of soft tissue edema
- Perform cryotherapy, compression and elevation regularly to assist in the reduction of soft tissue edema

PHASES OF MACI REHABILITATION PLAN

PHASE III: (WEEKS 4–6 POST-OPERATIVE)

During Phase III, the patient increases weight-bearing and range-of-motion activities, as appropriate, while augmenting strengthening exercises.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN:

PHASE III

GOALS

By Week 6 post-operative, patients are expected to achieve:

1. Pain-free active knee flexion to 125°.
2. Proficiency in performing home exercises, including a straight-leg raise.
3. Pain-free gait using 1–2 crutches (dependent on weight-bearing [WB] status), a knee brace and 60% body weight (BW) pressure for tibiofemoral (TF) grafts. Patients with patellofemoral (PF) grafts may be progressed to full WB as tolerated, following clearance from the orthopedic specialist.

REHABILITATION PLAN

WEIGHT BEARING

- TF joint: progress from 40% BW (Week 4) to 60% BW (Week 6)
- PF joint: progress from 75% BW (Week 4) to full WB (Week 6)

AMBULATORY AIDS

- TF joint: 1–2 crutches
- PF joint: 1–2 crutches (Weeks 4 and 5); 1 crutch as required (beginning at Week 6)

RANGE OF MOTION (ROM)

- TF joint: progress active ROM from 110° (Week 4) to 125° (Week 6)
- PF joint: progress active ROM from 90° (Week 4) to 125° (Week 6)

PHASES OF MACI REHABILITATION PLAN:

PHASE III

PROTECTIVE KNEE BRACING

- TF joint: progress brace from 0–60° (Week 4) to full flexion (Week 6)
- PF joint: use brace as required (beginning at Week 6)

ROM AND FLEXIBILITY EXERCISES

- Continue Phase I and II flexibility/stretching exercises
- Stretch hamstrings and calf musculature
- Carefully mobilize patella in all directions
- Use continuous passive motion (CPM) to maximum comfortable range as required

STRENGTHENING EXERCISES

- Continue Phase I and II strengthening exercises
- Progress straight-leg-raise activities (ie, supine straight-leg hip-flexion half-seated and/or with externally rotated foot)
- Introduce side-lying gluteal exercises with a flexed knee
- Introduce standing-calf raises (dependent on WB status)

- Introduce seated or standing weighted-hip adduction and abduction
- Introduce trunk-strengthening exercises
 - Supine sit-ups
 - Weight-supported trunk flexion
- Introduce recumbent cycling (modified knee flexion; 90°) (Weeks 5–6)

HYDROTHERAPY EXERCISES

- Continue Phase II hydrotherapy exercises
- Introduce active knee flexion (with floatation devices for additional resistance)
- Introduce shallow-water walking (waist depth, dependent on WB status)
- Introduce shallow-water calf raises
- Introduce deep-water squatting activities
- Introduce pool cycling (full knee ROM)

ADJUNCT MODALITIES

- Perform clearance and lymphatic remedial massage as required
- Perform cryotherapy, compression, and elevation as required

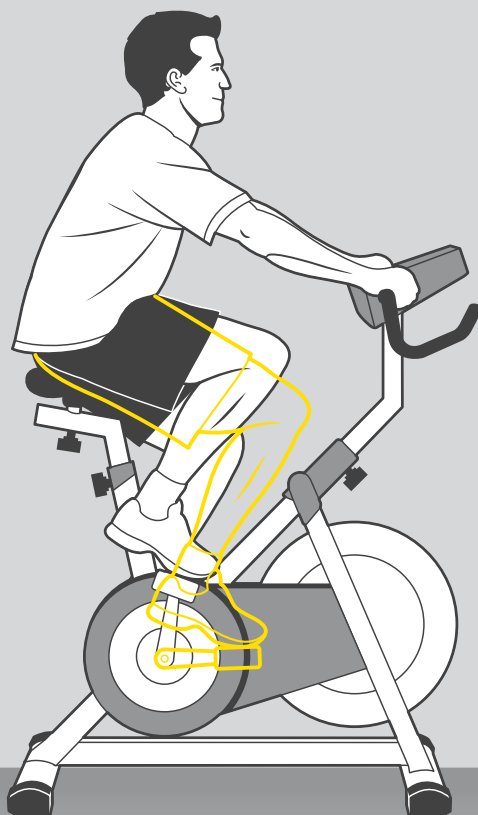


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PHASES OF MACI REHABILITATION PLAN

PHASE IV: (WEEKS 7–12 POST-OPERATIVE)

In **Phase IV**, the patient works toward movement independent of ambulation devices and knee braces. Focus is also placed on becoming thoroughly proficient with the rehabilitation exercises, as clinic visits become less frequent.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN:

PHASE IV

GOALS

By Week 12 post-operative, patients are expected to achieve:

1. Pain-free active knee range of motion (ROM) within anatomical limits (0° to 130–160°).
2. Pain-free six-minute walk test^{8,9} without the use of walking aids.
3. Pain-free upright cycle ergometry, without the protective knee brace.
4. Proficiency in performing home and gym-based exercises, for continuation of rehabilitation following clinic discharge.

Following the completion of Phase IV, patients generally undergo a 3-month post-operative assessment, and a written report is sent to the orthopedic specialist to coincide with the patient's review.

REHABILITATION PLAN

WEIGHT BEARING

- Tibiofemoral (TF) joint: progress from 80% body weight (BW) (Week 7) to full weight bearing (WB) (Weeks 8–10)
- Patellofemoral (PF) joint: full WB

AMBULATORY AIDS

Upon clearance from the orthopedic specialist, patients with TF are generally permitted to fully weight bear indoors without crutches, though a single crutch outdoors and in unfamiliar areas is encouraged.

- TF joint: 1 crutch as required in outdoor/unfamiliar areas (beginning Week 8)
- PF joint: no crutches

RANGE OF MOTION (ROM)

- TF joint: progress to full active knee ROM (Weeks 7–8)
- PF joint: progress to full active knee ROM (Weeks 7–8)

PHASES OF MACI REHABILITATION PLAN:

PHASE IV

PROTECTIVE KNEE BRACING

- TF joint: allow full knee flexion within brace
- PF joint: no brace

ROM AND FLEXIBILITY EXERCISES

- Continue Phase II–III flexibility/stretching exercises
- Stretch quadriceps musculature (Weeks 9–10)
- Introduce passive knee ROM on rowing ergometer (Weeks 9–10)
- Carefully mobilize patella in all directions
- Conduct continuous passive motion (CPM) to maximum comfortable range as required

STRENGTHENING EXERCISES

- Continue Phase II–III strengthening exercises
- Introduce standing weighted hip adduction and abduction
- Introduce weighted knee flexion (Week 8)
- Introduce upright (knee flexion: 105–110°) cycling (Weeks 9–12)

HYDROTHERAPY EXERCISES

- Continue Phase II–III hydrotherapy exercises
- Stretch quadriceps musculature
- Progress water squatting activities
- Introduce weight-supported lunge activities
- Introduce weight-supported “step up and down” activities
- Introduce “patter” kick (Week 12)

ADJUNCT MODALITIES

- Perform clearance and lymphatic remedial massage as required
- Perform cryotherapy, compression and elevation as required

PROPRIOCEPTION EXERCISES

Introduced following the return to full WB, both within the hydrotherapy pool and the clinic setting, these activities should be undertaken on both the affected and non-affected leg. Slowly progress proprioceptive activities from partial to full WB positions by altering:

1. The patient’s postural position (ie, seated to standing).
2. The environment in which the activity is to be undertaken (ie, gym- or pool-based).
3. Proprioceptive input mechanisms (ie, eyes open or closed).
4. The speed of movement.
5. The magnitude of the base of support (ie, 2-legged to 1-legged).
6. The stability of the base of support (ie, introduction of unstable surfaces including a soft mat or pillow, wobble board, dura disc, theraball or mini-trampoline).
7. Introducing “weight transfer” and/or “activity-specific drills” with other equipment.

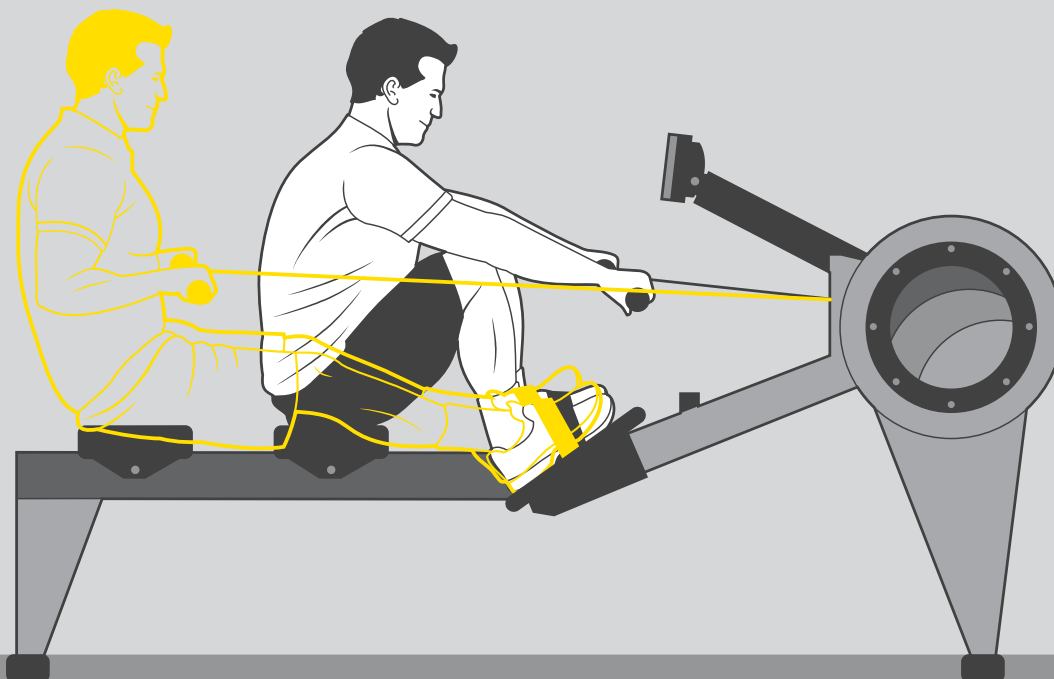


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PHASES OF MACI REHABILITATION PLAN

PHASE V: (MONTHS 3–6 POST-OPERATIVE)

During these months, the majority of patients return to work either on a part-time or full-time basis. Therefore, patients either continue to attend the outpatient clinic once or twice per week independently (though group supervised), or should continue with their prescribed gym and home rehabilitation program independently.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN: PHASE V

GOALS

By 6 months post-operative, patients are expected to achieve:

1. Normal gait pattern without pain, walking aids or a knee brace.
2. Ability to negotiate stairs and mild gradients.
3. A return to work, depending on the demands of the job.
4. Proficiency in performing a weighted-leg press through 60–90° of knee flexion, and with up to (though no more than) 50% of body weight (BW) pressure.
5. Proficiency in performing full weight-bearing (WB) proprioception activities.

REHABILITATION PLAN

WEIGHT BEARING

- Tibiofemoral (TF) and patellofemoral (PF) joint: full WB

AMBULATORY AIDS

- TF and PF joint: no crutches

RANGE OF MOTION (ROM)

- TF and PF joint: full and pain-free active knee ROM

PROTECTIVE KNEE BRACING

- TF and PF joint: no brace

ROM AND FLEXIBILITY EXERCISES

- Continue Phase III–IV flexibility/stretching exercises

PHASES OF MACI REHABILITATION PLAN: PHASE V

STRENGTHENING EXERCISES

- Continue Phase III–IV strengthening exercises
- Introduce bridging exercises
- Introduce standing single-leg calf raises
- Introduce modified open kinetic-chain (OKC) exercises (eg, terminal leg extension, with appropriate use based on lesion location and knee joint biomechanics)
- Introduce modified closed kinetic-chain (CKC) exercises (eg, inner range quadriceps and leg press activities)
- Progress upright stationary and outdoor road cycling
- Introduce rowing ergometry as tolerated

HYDROTHERAPY EXERCISES

- Generally not required from Week 12, though the pool may be used for ongoing cardiovascular exercise

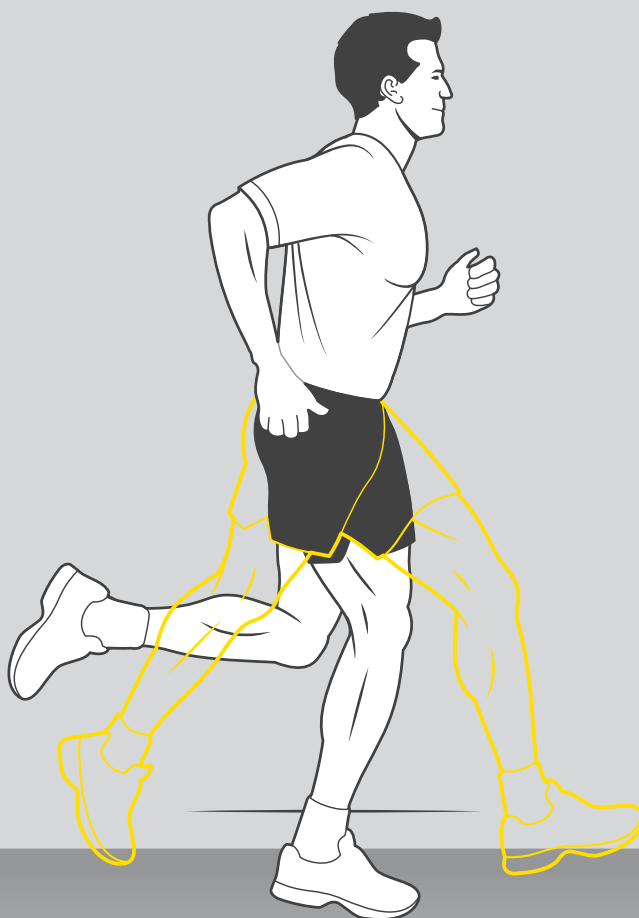


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PHASES OF MACI REHABILITATION PLAN

PHASE VI: (MONTHS 6–9 POST-OPERATIVE)

In this phase, gradually increasing the difficulty of the exercises, the patient returns to pre-operative low-impact recreational activities.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN: PHASE VI

GOALS

By 9 months post-operative, patients are expected to achieve:

1. Hamstring and calf strength within 80–90% of the contralateral leg.
2. Ability to tolerate walking distances of more than 5–10 km (3.1–6.2 miles).
3. Ability to effectively negotiate uneven ground, including soft sand.
4. Ability to return to pre-operative low-impact recreational activities.

REHABILITATION PLAN

RANGE OF MOTION (ROM) AND FLEXIBILITY EXERCISES

- Continuation of Phase III–IV flexibility/stretching exercises

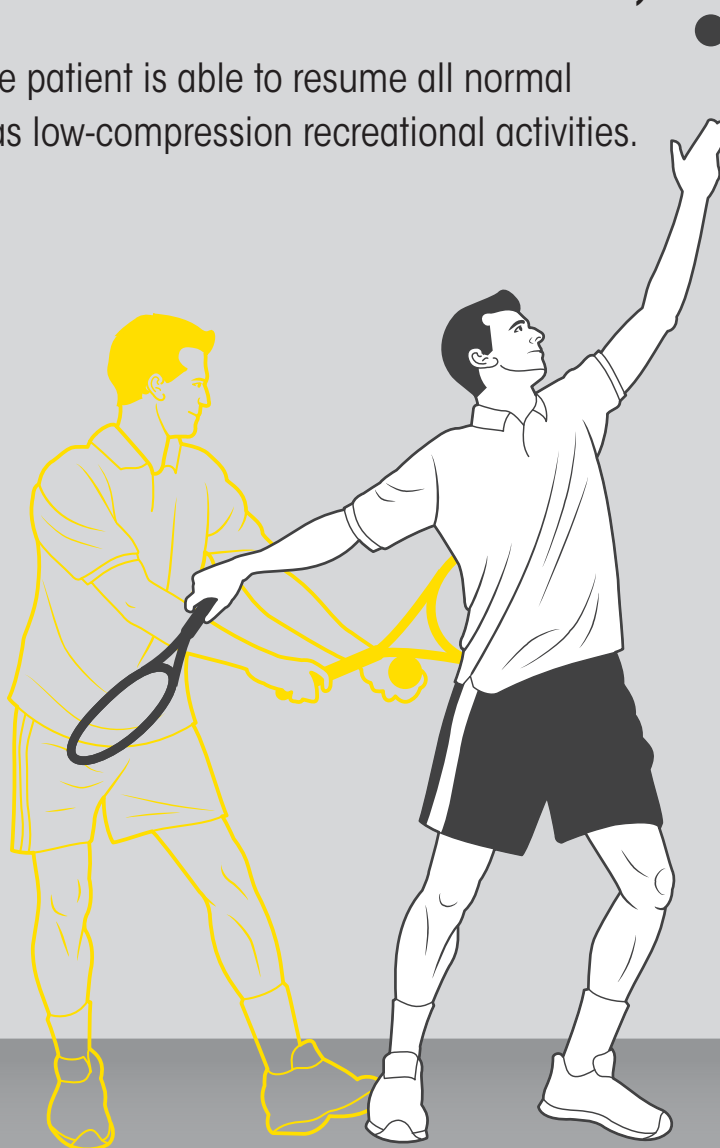
STRENGTHENING EXERCISES

- Continuation of Phase III–V strengthening exercises
- Progression and increased difficulty of open kinetic-chain (OKC) exercises
- Progression and increased difficulty of closed kinetic-chain (CKC) exercises (ie, step ups/downs, modified squat activities)
- Introduction of controlled running on a mini-trampoline

PHASES OF MACI REHABILITATION PLAN

PHASE VII: (MONTHS 9–12 POST-OPERATIVE AND RETURN TO ACTIVITIES)

In the final phase, the patient is able to resume all normal functionality, as well as low-compression recreational activities.



Please see accompanying Important Safety Information and full Prescribing Information.

PHASES OF MACI REHABILITATION PLAN: PHASE VII

GOALS

By 12 months post-operative, patients are expected to achieve:

1. Ability to perform all activities of daily living.
2. Ability to commence a return to a running program, for example: walk/jog, jog/run, run on soft surface (grass or soft sand only).
3. Resumption of dynamic recreational activities (however, activities that generate high compression, shear and rotational loads are to be avoided until 12–18 months, or as directed by the orthopedic surgeon).

REHABILITATION PLAN

RANGE OF MOTION AND FLEXIBILITY EXERCISES

- Continuation of Phase III–VI flexibility/stretching exercises

STRENGTHENING EXERCISES

- Continuation of Phase III–VI strengthening exercises
- Progression and increased difficulty of close kinetic-chain (CKC) exercises (ie, lunge and squat activities on unstable surfaces)
- Introduction of agility exercises relevant to the patient's activities

PHASES OF MACI REHABILITATION PLAN: PHASE VII

RETURN TO ACTIVITIES*

At this stage patients are gradually reintroduced to their functional activities. In this final phase the patient should be able to resume normal functionality as well as low compression recreational activities. These activities are initially performed in isolation, and then with the appropriate equipment.

It is not the purpose of this document to outline a protocol of specific exercises and activities. Both the patient and therapist must use their own discretion. Not only the graft maturation process, but the mental preparedness of the patient and the general physical function and level of specific knee strength, stability and support, among other individual patient variations, must be evaluated when considering a patient's long-term outcome and ability to return to activities. Specific considerations include whether:

1. The patient's graft has matured to the point at which it is able to withstand the specific demands of the chosen activity.
2. The patient has been appropriately rehabilitated to the point at which he or she is able to physically undertake the demands of the chosen activity.
3. The commitment and psychological profile of the patient.
4. The patient has undergone appropriate clinical assessment with an orthopedic specialist experienced with the results of a MACI implant.

Cellular regeneration, matrix production and adaptation of the regenerating tissue to natural function take time, and it is unrealistic and impractical to expect patients to return to their normal activities within the first post-operative year.

*Individual results may vary.



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ADDITIONAL READING
REFERENCES
IMPORTANT SAFETY INFORMATION

Please see accompanying Important Safety Information and full Prescribing Information.

RECOMMENDED READINGS

Ebert JR, Robertson WB, Lloyd DG, Zheng MH, Wood DJ, Ackland T. A prospective, randomized comparison of traditional and accelerated approaches of post-operative rehabilitation following autologous chondrocyte implantation: 2-year clinical outcomes. *Cartilage*. 2010;1:180-187.

Ebert JR, Fallon M, Robertson WB, Lloyd DG, Zheng MH, Wood DJ, Ackland T. Radiological assessment of accelerated versus traditional approaches to post-operative rehabilitation following matrix-induced autologous chondrocyte implantation. [published online ahead of print October 18, 2010]. *Cartilage*. doi:10.1177/1947603510380902.

Ebert JR, Robertson WB, Lloyd DG, Zheng MH, Wood DJ, Ackland T. Traditional vs accelerated approaches to post-operative rehabilitation following matrix-induced autologous chondrocyte implantation (MACI): comparison of clinical, biomechanical and radiographic outcomes. *Osteoarthritis Cartilage*. 2008;16:1131-40.

Ebert JR, Ackland TR, Lloyd DG, Wood DJ. Accuracy of partial weight bearing after autologous chondrocyte implantation. *Arch Phys Med Rehabil*. 2008;89(8):1528-34.

Hambly K, Bobic V, Wondrasch B, Van Assche D, Marlovits S. Autologous Chondrocyte Implantation Post-operative Care and Rehabilitation: Science and Practice. *Am J Sports Med*. 2006;34:1-19.

Reinold MM, Wilk KE, Macrina LC, Dugas JR, Cain EL. Current concepts in the rehabilitation following articular cartilage repair procedures in the knee. *J Orthop Sports Phys Ther*. 2006;36(10):774-94.

Riegger-Krugh CL, McCarty EC, Robinson MS, Wegzyn DA. Autologous chondrocyte implantation: current surgery and rehabilitation. *Med Sci Sports Exerc*. 2008;40(2):206-14.

Wondrasch B, Zak L, Welsch G, Marlovits S. Effect of Accelerated Weightbearing After Matrix-Associated Autologous Chondrocyte Implantation on the Femoral Condyle on Radiographic and Clinical Outcome After 2 Years. A Prospective, Randomized Controlled Pilot Study. *Am J Sports Med*. 2009.

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6. Minas T. The role of cartilage repair techniques, including chondrocyte transplantation, in focal chondral knee damage. *Instructional Course Lectures.* 1999;48:629-43.
7. Ebert JR, Ackland T, Lloyd DG, Wood DJ. Accuracy of partial weight bearing after autologous chondrocyte implantation. *Arch Phys Med Rehabil.* 2008;89(8):1528-34.
8. Ebert JR, Robertson WB, Lloyd DG, Zheng MH, Wood DJ, Ackland T. Traditional vs accelerated approaches to post-operative rehabilitation following matrix-induced autologous chondrocyte implantation (MACI): comparison of clinical, biomechanical and radiographic outcomes. *Osteoarthritis Cartilage.* 2008;16:1131-40.
9. Enright PL. The six-minute walk test. *Respir Care.* 2003;48(8):783-5.

IMPORTANT SAFETY INFORMATION

INDICATION FOR USE

- MACI® (autologous cultured chondrocytes on porcine collagen membrane) is an autologous cellularized scaffold product that is indicated for the repair of single or multiple symptomatic, full-thickness cartilage defects of the adult knee, with or without bone involvement.
- MACI is intended for autologous use and must only be administered to the patient for whom it was manufactured. The implantation of MACI is to be performed via an arthrotomy to the knee joint under sterile conditions.
- The amount of MACI administered is dependent upon the size (surface in cm²) of the cartilage defect. The implantation membrane is trimmed by the treating surgeon to the size and shape of the defect, to ensure the damaged area is completely covered, and implanted cell-side down.

Limitations of Use

- Effectiveness of MACI in joints other than the knee has not been established.
- Safety and effectiveness of MACI in patients over the age of 55 years have not been established.

IMPORTANT SAFETY INFORMATION

- MACI is contraindicated in patients with a known history of hypersensitivity to gentamicin, other aminoglycosides, or products of porcine or bovine origin. MACI is also contraindicated for patients with severe osteoarthritis of the knee, inflammatory arthritis, inflammatory joint disease, or uncorrected congenital blood coagulation disorders. MACI is also not indicated for use in patients who have undergone prior knee surgery in the past 6 months, excluding surgery to procure a biopsy or a concomitant procedure to prepare the knee for a MACI implant.
- MACI is contraindicated in patients who are unable to follow a physician-prescribed post-surgical rehabilitation program.
- The safety of MACI in patients with malignancy in the area of cartilage biopsy or implant is unknown. Expansion of present malignant or dysplastic cells during the culturing process or implantation is possible.
- Patients undergoing procedures associated with MACI are not routinely tested for transmissible infectious diseases. A cartilage biopsy and MACI implant may carry the risk of transmitting infectious diseases to healthcare providers handling the tissue. Universal precautions should be employed when handling the biopsy samples and the MACI product.

IMPORTANT SAFETY INFORMATION (continued)

- Final sterility test results are not available at the time of shipping. In the case of positive sterility results, health care provider(s) will be contacted.
- To create a favorable environment for healing, concomitant pathologies that include meniscal pathology, cruciate ligament instability and joint misalignment, must be addressed prior to or concurrent with the implantation of MACI.
- Local treatment guidelines regarding the use of thromboprophylaxis and antibiotic prophylaxis around orthopaedic surgery should be followed. Use in patients with local inflammations or active infections in the bone, joint, and surrounding soft tissue should be temporarily deferred until documented recovery.
- The MACI implant is not recommended during pregnancy. For implantations post-pregnancy, the safety of breast feeding to infant has not been determined.
- Use of MACI in pediatric patients (younger than 18 years of age) or patients over 65 years of age has not been established.
- The most frequently occurring adverse reactions reported for MACI ($\geq 5\%$) were arthralgia, tendonitis, back pain, joint swelling, and joint effusion.
- Serious adverse reactions reported for MACI were arthralgia, cartilage injury, meniscus injury, treatment failure, and osteoarthritis.



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