Steps to Success: A Guide to Knee Rehabilitation
**Indications**

Carticel® (autologous cultured chondrocytes) is indicated for the repair of symptomatic, cartilaginous defects of the femoral condyle (medial, lateral, trochlear), caused by acute or repetitive trauma, in patients who have had an inadequate response to a prior arthroscopic or other surgical repair procedure. Carticel is not indicated for the treatment of cartilage damage associated with osteoarthritis.

**Warnings/Precautions**

Carticel is not recommended for use in patients with known history of allergy to the antibiotic gentamicin, in patients with sensitivities to materials of bovine origin, who have an unstable knee, or who have abnormal weight distribution within the joint. Patients who have previously had cancer in the bones, cartilage, fat, or muscle of the treated limb should also not be treated with Carticel. Any instability of the knee or malalignment of the joint should be corrected before or concurrent with Carticel implantation. Use in children or in joints other than the knee has not yet been assessed. Data regarding outcomes beyond 3 years are limited. In patient data included in the biologics license application, the following were the most frequently reported adverse events: “overgrown” tissue at the site of the cartilage repair, adhesions, superficial wound infection, inflammation of membranes within the joint, and post-operative bruising. See accompanying package insert for complete prescribing information.
**Introduction**

Like most other orthopedic surgeries, rehabilitation after Carticel (autologous cultured chondrocytes) implantation is critical to the healing process and the success of the procedure. While the recovery period can be extensive and needs commitment as with other knee implants associated with weight bearing surfaces, most patients can perform necessary low impact activities like walking or driving relatively early in the program. Return to work depends on the demands placed on the implanted knee.

It is important to consider that implantation of Carticel is a biological repair. The maturation process of the implanted cells cannot be accelerated through rehabilitation. In the first six weeks, the tissue is very soft, delicate and quite fragile. Gradually, the tissue begins to mature and harden from a gelatin-like consistency to putty-like consistency. The rehabilitation is guided toward protecting the repair surface to allow natural maturation while motion, muscle control, and muscle strength are slowly returned. A patient's recovery depends on size, severity, and location of the cartilage injury, patient age, physical condition prior to surgery, and the affected knee (right or left).

In the first six weeks or early stage, patients should protect their weight from loading the implant by using crutches. Motion is important to prevent the formation of adhesions and stiffness, hence, daily use of a continuous passive motion (CPM) machine is recommended. Isometric exercises are utilized to regain muscle control and tone. Manual manipulation and massage around the scar and particularly mobilization of the knee cap is recommended to help prevent formation of adhesions.

The transition phase, approximately week 13 - 6 months post implantation, stresses developing greater strength in the muscles that support your knee. Your tolerance for standing and the amount you walk should also increase. At any time during the rehabilitation process, if pain, catching, or swelling increase with increased weight on the implanted knee, the amount of weight should be immediately decreased. Pain and discomfort are indicators that the implant may be overloaded.

During the final phase, approximately 10-18 months post implantation, the use of your knee may begin to feel more natural. Muscle strengthening exercises and more aggressive resistance training are now permitted.

Patients should continue to think about the biologic process and maturation of the tissue. Recovery with a rehabilitation program that is consistent yet conservative may yield a more successful outcome. It is important to be cautious when accelerating the program. Just because pain may have subsided, the fragility of the repair tissue must remain the primary concern. Accelerating the program too early may damage the implant. This philosophy is dramatically different from most programs that tend to be aggressive and limit physical activity only by tolerance to pain.

Please note that the lesion size, location and patient age are significant factors in determining a rehab program for each patient. Based on your needs and expectations, your surgeon and physical therapist will take these factors into consideration and use the following pages as a guideline to develop a program that is right for you.

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Reminders

Always consult your surgeon or physical therapist with questions or concerns and if you experience pain with locking or swelling during the rehabilitation process. Specific notes are included, but in general, you should minimize activities that cause either. Should you experience these symptoms, be sure to tell your surgeon or physical therapist, and adjust your rehabilitation work to allow for more gradual progress.

Before getting started, some final cautions: 1) Individual results will vary. Not all patients achieve full function. 2) Know your surgery. These guidelines are for femoral condyle rehabilitation. See notes throughout if you’ve had trochlear repair. This rehab program is not for patello-femoral joint repair. 3) Always consult your surgeon for a specific rehabilitation program.

Getting Started

Your mobility will be limited the first few days, so get help with the following:

• Head home with a continuous passive motion (CPM) machine. You will need to use it every day for the initial phase of your rehabilitation.

• Have the CPM machine set up where you will enjoy spending long periods of time – in front of your favorite view, near a TV or stereo, or in the center of household activity.

• Find a location where your crutches are easy to reach.

• Get help clearing the major walkways you’ll use around the house, including routes to the CPM machine, bathroom, dining table, and your bed.

• Prepare lots of ice packs, such as resealable plastic bags or re-useable ice packs. Applying ice to the joint after therapy will help control swelling and pain.

Note: Some terms used in the text may not be familiar to you. See page 14 for a Glossary.
Early Phase: Day 1 to approximately Week 12
Overview: Your rehabilitation begins once you arrive home from surgery. It will consist of a series of progressive weight bearing, range of motion, muscle strengthening and cardiovascular exercises.

By the end of this phase you should have nearly full ability to bend and straighten your knee. Your strength should also improve gradually. Crutch support may be eliminated by Week 12. (Early Phase exercises appear on pages 6-7.)

Walking/weight bearing
Use both crutches for at least 4-7 weeks. Use straight leg brace as recommended; lock completely straight (at 0°). Apply minimal weight to implanted leg — 30-40 lbs or 16-22 kg, about one quarter of body weight for the first three weeks. Gradually work up to full weight bearing by Week 12. Maintain use of brace until the quadriceps are strong enough to control the leg in a straight leg raise (SLR). If there is joint pain or swelling associated with walking, use either a crutch or cane.

Range of motion
Start CPM within 6-24 hours following surgery. Settings: femoral condyle, 0° extension to 40-45° flexion; trochlear, 0° extension and 30° flexion, not to exceed 45°.
Use CPM 8-10 hours a day for first two weeks in two-hour sessions.
Increase CPM settings 5° to 10° per day as pain allows. Goal is 90° of flexion by Week 4, 110° by Week 5.
Use assisted range of motion exercises by flexing and extending the knee in a supported fashion. Gradually advance to the point where you feel comfortable.
Maintain flexibility and mobility of your other leg and of the joints unaffected by the surgery (ankle and hip) of the implanted leg.
Trochlear repair: Allow the leg to hang over the edge of the bed to increase bending motion. Goal is to reach 90° flexion by Week 4. Be careful not to get stiff, but don’t push beyond point of pain.

Strengthening
Contract quadriceps (isometrics) without moving the knee joint. This will help to gain strength and muscle tone.
Start muscle work in short and selective range exercises that do not “load” or irritate the repair site. Consult your physical therapist or surgeon.
Quad control goal by Week 3-4 is to be able to do a straight leg raise with the knee locked perfectly straight.
Isometric exercises may begin at Week 6, if they can be done without joint pain. Position foot in a fixed position at varying angles (using the floor, wall, platform or pedal).
Trochlear repair: Concentrate on isometrics (quad contractions) only.
Cardiovascular

Once 90° of knee flexion is achieved, cycle using light resistance.

Train on stairs, hills, or uneven ground with use of crutches or other support. Water activities may include straight leg swim and kick.

**Trochlear:** Do not cycle; continue to work on range of motion only.

**Pain and swelling**

If you experience swelling, use anti-inflammatory measures like icing, elevation, and compressive wraps. These measures should be used throughout the Early Phase as well as regularly throughout your entire rehabilitation. Ice can also be used to control pain; regular use after exercise sessions may reduce later discomfort. If the next level of increased activity / exercise cause pain, decrease the activity / exercise to the former level until the pain resolves.
Continuous Passive Motion (CPM)

Objective: To feel some tissue stretching, but no pain

1) Lie flat on firm surface with machine on same surface.
2) Place heel snugly in holder; strap is placed across your shin.
3) It is essential that leg and foot are in a straight line – do not turn foot.
4) Use machine as directed. Progressively increase flexion as recommended.

➢ Start at eight hours a day, in two-hour sessions. Increase flexion by 5° to 10° a day as pain allows.

Straight Leg Raise

Objective: To feel stretching in the thigh

1) Lie on your back on a firm surface.
2) Bend uninvolved knee.
3) Keeping implanted leg straight and locked, raise 12–15 inches off the floor.
4) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.

Hip Abduction Top Leg

Objective: To feel some stretching in the thigh and calf muscles

1) Lie on your uninvolved side on a firm surface.
2) Bend uninvolved leg at knee as shown.
3) Raise implanted leg 18-24 inches off floor.
4) Keep your knee straight and locked; point your toes if you can.
5) Lower leg slowly to starting position, relax and repeat.

➢ Do one set of 10, three times a day.
Sidelying Hip Abduction Bottom Leg

Objective: To feel some stretching in the thigh and calf muscles

1) Lie on your implanted side on a firm surface.
2) Bend uninvolved leg at knee as shown, and place it behind your implanted leg.
3) Raise implanted leg 6–10 inches off the floor.
4) Keep your knee straight and locked, point your toes if you can.
5) Lower leg slowly to starting position, relax and repeat.

➢ Do one set of 10, three times a day.
Transition Phase: approximately Week 13 - 6 Months*
Overview: Your crutches may now be gone. This phase will stress developing greater strength in the muscles that support your knee. Your tolerance for standing and the amount you walk should also increase.

Follow the steps below, coordinating with your physical therapist. As before, stop when you feel pain and watch for swelling.

*Time varies depending on implant size, depth and location. Consult your surgeon or physical therapist.

Walking/weight bearing
Work toward walking while bearing full weight.
Once you’re comfortable walking free of your crutches, you may being to train on a treadmill at a slow pace.
Trochlear repair: Treadmill use is allowed after Week 12. Limit to walking, especially retro-walking (walking backward).

Range of motion
Pursue full range of motion exercises such as cycling.
Continue stretching exercises for the entire leg: hip, quads, hamstring and calves.

Strengthening
Loads placed on your knee should be less than your total body weight.
Progress to holding squats (isometric).
Advance single leg press to dynamic repetitions, moving the knee through a limited arc of motion.
Trochlear repair: Limit dynamic repetition training until Month 4.

Cardiovascular
Cycle with both legs at normal settings.
For stair climber and rower: Start with shortened arcs of motion and progress for endurance and greater arcs of motion.
For treadmill: Walk at slight incline (2-3°) to reduce joint loads.
Gradually increase resistance exercises for hamstring, calves, hip and upper quad work as desired for total body fitness.

Pain and swelling
During the transition phase, you should begin to feel confident in your quad control and continue to increase endurance without pain or swelling. If you experience pain or swelling decrease your activity / exercise to the former level until pain resolves. As recommended by your surgeon, continue the use of anti-inflammatory measures.
Transition Phase: Prone Knee Flexion

Objective: To feel some tissue stretching in the knee

1) Lie flat on your stomach on firm surface.
2) Uninvolved leg is flat and straight.
3) Bend implanted leg, pointing toes to the ceiling.
4) Do not bend beyond 90°.
5) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.

Resisted Hip Abduction

Objective: To feel stretching in the calf and thigh muscles

1) Attach Theraband to stationary object. Place loop around implanted leg at the ankle.
2) Stand with feet flat on a firm surface.
3) Lift implanted leg out to the side.
4) Keep leg straight and knee locked.
5) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.

Resisted Hip Extension

Objective: To feel stretching in the calf and thigh muscles

1) Attach Theraband to stationary object, and place loop around implanted leg at the ankle.
2) Stand with feet flat on a firm surface.
3) Keeping heel of uninvolved foot flat on the floor, lift implanted leg out behind you with toe pointed.
4) Keep leg straight and knee locked.
5) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.
Mid Phase: Approximately 7 Months - 9 Months

Overview: The exercises in this phase will make you stronger and more stable. The overall cardiovascular benefits to your fitness should start to improve energy levels.

There will be a steady addition of strength training at moderate levels. The goal is to increase your muscle bulk strength and increase your tolerance for prolonged standing and walking. We recommend a full evaluation with your physical therapist and surgeon at the end of this period to develop a complete plan for the next nine months.

Walking/weight bearing
Walk with treadmill on an incline. Gradually increase speed to achieve mild “impact” tolerance without running.

Range of motion
Continue cycling.
Continue to work on patellar and soft tissue mobility and joint flexibility.

Strengthening
Increase work loads on knees. Use a variety of exercises that flex and extend the knee with resistance.
Progress to more advanced workouts, with a variety of dynamic exercises with lower leg machines such as leg sled, press and curls. Add non-gym exercises, such as squats and other isometric exercises that don’t require equipment.

Cardiovascular
Continue transition phase activities, increasing length of time on cardiovascular activities to 45 minutes.
Consider cross training by mixing cycle, stair climber, and treadmill (for fast walk).

Pain and swelling
Continue to keep pain and swelling under control as described earlier in the guide. As your strength increases, your desire to do more may increase as well. Monitor pain and swelling regularly and adjust your activity levels as needed. If you experience pain or swelling decrease your activity / exercise to the former level until pain resolves. If you experience unusual symptoms, contact your surgeon and/or physical therapist.
Quarter Squats
Objective: To feel some stretching in the thigh muscles
1) Stand with feet flat on a firm surface.
2) Keep heels flat on the floor; bend your knees to 30° as shown.
3) Maintain your balance and bend your knees straight over your feet. Bend slowly and steadily.
4) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.

Quarter Squats with Theraband
Objective: To feel some stretching in the thigh muscles
1) Attach Theraband to stationary object.
Place loop around leg and behind implanted knee.
2) Stand with feet flat on a firm surface.
3) Keep heels flat on the floor; bend your knees to 30° as shown.
4) Maintain your balance and bend your knees straight over your feet. Bend slowly and steadily.
5) Return to starting position, relax and repeat.

➢ Do one set of 10, three times a day.

Ski Exercise
Objective: To feel some stretching in the thigh and calf muscles
1) Stand with feet flat on a firm surface about 18 inches apart.
2) Keep heels flat on the floor and place hands on hips.
3) Keep feet straight and bend knees over the toes.
4) Take hand and slide down over thigh to inner thigh as you twist at the waist. The knee on the leg you’re touching should bend and bear your weight.
5) Return to starting position and repeat with other hand, bending other knee.

➢ Do one set of 10, three times a day.
Final Phase: Approximately 10 Months - 18 Months

Overview: As you move toward completion of your rehabilitation, the use of your knee may feel natural. Confidence in the strength and functional recovery of your knee will be justified by completing the steps here and resuming an active lifestyle.

At this stage, a plan to maintain muscle bulk is essential. Lateral motion is added to all that you've achieved with strength, range of motion, and fitness. Individual results will vary – not all patients achieve full function.

**Walking/weight bearing**

Begin impact training with fast walks or light jogs on the treadmill using a slight incline to help reduce impact load.

If you are not experiencing pain or swelling, extend walking and jogging distances.

**Strengthening**

Progress to advanced training with heavier weights and fewer repetitions to increase muscle mass. Use weights equal to body weight and sets of 8-10 repetitions.

Emphasize single leg loading and full weight bearing.

Ask your physical therapist to help develop a strengthening program that will satisfy your goals.

**Cardiovascular**

Start activities that include jumping and lateral movement (shuttling).

Determine functional goals needed for specific activities and work with your physical therapist to develop a program that will achieve these goals.

Consult with your surgeon for guidelines on returning to full, unhindered work and sports activities.

**Pain and swelling**

Continue to be aware of pain and swelling as you did in all other phases. Keep these symptoms under control with ice after all exercise. If you experience pain or swelling decrease your activity / exercise to the former level until pain resolves. Any major setbacks should be reported to your surgeon or physical therapist.
Lunge

Objective: To feel some stretching in the thigh and calf muscles

1) Stand with feet flat on a firm surface.
2) Keeping uninvolved heel flat on the floor, step forward, bending your implanted knee.
3) Bend at 30° to start; increase with physical therapist input only.
4) Maintain your balance and bend your knees straight over your feet. Bend slowly and steadily.
5) Return to starting position, relax and repeat.

Do one set of 10, three times a day.

Single Leg Step

Objective: To feel some stretching in knee, and thigh and calf muscles

1) Place an object such as a phone book on a firm surface.
2) Stand on object with both feet.
3) With uninvolved leg, step off, placing heel on the floor 3–4 inches in front of book.
4) The implanted leg bends at the knee at 30° as shown.
5) Return to starting position with both feet and repeat.

Do one set of 10, three times a day.
**Additional Activities**

If your interest in specific sports has been limited by your surgery, the following guidelines may help you work toward your return to those activities. Depending on individual progress, some of these timelines may not be appropriate; consult your surgeon and physical therapist. All of these activities place more stress on the knee. **DO NOT** rush into these without approval.

Your surgeon and physical therapist can provide you with additional reading material, instructions and guidelines as you progress through your rehabilitation.

Low impact: after 9-12 months
- skating
- rollerblading
- cross-country skiing
- cycling (road)

Repetitive impact: after 12-15 months
- jogging
- running
- aerobic classes

High impact: after 15-18 months
- tennis
- basketball

Remember: Individual results may vary. Not all patients achieve full function.

**GLOSSARY**

**Calf muscles, calves**
The muscle group below your knee, behind your shin bone. Responsible for extending your foot. Strengthening this group will make you more stable on your feet.

**Cardiovascular, cardio**
Refers to the health of your heart and blood vessels, which carry oxygen to your muscles.

**Continuous passive motion, CPM**
CPM refers to the use of a machine to help restore extension and flexion or complete motion to your knee without the use of muscle groups. This is a vital part of the early phase of your rehabilitation.

**Elevation**
In either a seated or prone position (lying down), elevate your foot up so it is higher than your hip. This will help to minimize swelling.

**Femoral condyle**
A rounded knob found at the end of the thigh bone in the knee joint. It is this surface, which is covered with cartilage, that is most frequently damaged, causing pain.

**Hamstrings, hams**
Two tendons that connect muscle to bone in the back of your thigh. The attached muscles are responsible for flexing or bending the knee.
Icing, cryotherapy
Applying ice to the joint after exercise. This will reduce pain and swelling. To protect your skin, always keep a barrier such as a cloth (towel, pants, etc.) between the ice and your skin.

Isometric exercise
Tensing of a muscle or muscle group against an immovable object.

Non-weight bearing, NWB
Walking without applying any weight to the implanted leg or knee. This is achieved by using crutches and is necessary for the first several weeks following surgery.

Partial weight bearing, PWB
Walking with applying only minimal weight to the implanted leg or knee. This is achieved by continuing the use of crutches and allowing only “toe touch” weight bearing.

Patella
The knee cap.

Physical therapist, PT
A health professional who helps patients recover function following an injury or surgery. Physical therapists use exercise and other therapies to strengthen muscles and improve coordination and function.

Quadriiceps, quads
The large muscle group in front of your thigh. Responsible for knee extension and proper knee cap alignment.

Rehabilitation, rehab
The patient’s efforts in the recovery phase.

Trochlea
A center groove in the femoral condyle where the knee cap tracks, as the knee is flexed and extended. (See “femoral condyle”)