



Standard of Care: Autologous Chondrocyte Implantation (ACI)

Physical therapy management of the patient s/p ACI.

Case Type / Diagnosis: Autologous Chondrocyte Implantation (ACI)

ICD-9 Code: 718.0 –Articular cartilage disorder

APTA Practice Pattern: 4I-Impaired joint mobility, motor function, muscle performance, and range of motion associated with bony or soft tissue surgery.

There are two primary types of cartilage produced in the knee joint; hyaline cartilage and fibrocartilage. Articular cartilage, which is composed of hyaline cartilage, covers the joint surfaces of bones. The role of articular cartilage is to facilitate motion between two articular surfaces. Articular cartilage serves as a load-bearing surface to distribute loads rather than as a shock absorber. The unique mechanical properties of hyaline cartilage are due to its composition of chondrocytes, which produce a proteoglycan matrix and type II collagen. Articular cartilage must be both readily deformable in order to absorb weight-bearing forces and elastic to reform quickly after stress is removed. Articular cartilage may be compressed to as much as 40% of its original height under normal physiologic conditions.¹ Blood and lymphatic vessels are not able to tolerate this type of deformity or trauma and therefore articular cartilage lacks nerve endings and a blood supply. Once articular cartilage is damaged it cannot regenerate or repair itself to its original form.² This is due to the lack of blood supply and because the deeper layers of articular cartilage are calcified and nourishment cannot reach the cartilaginous cells from the underlying bone. The cartilage cells must obtain their nutrients and oxygen by long-range diffusion from outside the cartilage. Synovial fluid, which covers the surface of articular cartilage, serves as a medium for nutrients.¹

Lesions to articular cartilage can be painful, cause swelling, locking and catching and may progress to osteoarthritis resulting in limited functional activities.³ When osteoarthritis is severe the most common treatment for individuals over the age of 60 is replacement of the arthritic articular surfaces with prosthesis; total knee replacement (TKR). Because of the limited lifetime common to prostheses, younger patients are generally poor candidates.⁴

Abrasion, drilling and microfracture are techniques that have been used in the past in attempt to repair articular cartilage lesions. These techniques were unable to recreate the normal characteristics of hyaline cartilage and resulted in the formation of fibrocartilage instead. Fibrocartilage is inferior to hyaline cartilage because it can degenerate over time resulting in short-term, temporary relief of symptoms.⁵⁻⁷ The loadbearing capacity of fibrocartilage is only approximately 1/3 of hyaline cartilage making it susceptible to early breakdown, leading to recurrence of symptoms and an increase in size of the defect, thus requiring further knee surgery.^{5, 7, 8}

Other surgical techniques for treating cartilage lesions include arthroscopic debridement, osteochondral graft transfers, and autologous chondrocyte implantation (ACI). Lars Peterson MD and coworkers first developed the ACI technique in Sweden during the 1980's to delay the onset

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of degenerative osteoarthritis by allowing the regeneration of hyaline-like cartilage.^{6,9} In 1995 Dr. Tom Minas, presently of the Department of Orthopedic surgery at Brigham and Women's Hospital, performed the first knee cartilage transplant in the United States. He performed his 400th cartilage transplant at Brigham and Women's Hospital in June of 2006.

The FDA has approved the use of Carticel (autologous cultured chondrocytes) "for the repair of symptomatic cartilaginous defects of the femoral condyle (medial, lateral or trochlea), caused by acute or repetitive trauma, in patients who have had an inadequate response to a prior arthroscopic or other surgical repair procedure. Carticel should only be used in conjunction with debridement, placement of a periosteal flap and rehabilitation. Carticel is not recommended for the treatment of cartilage damage associated with generalized osteoarthritis."¹⁰ ACI has been found to be beneficial for cartilage injuries greater than 2 to 3 cm² and is currently being used to treat chondral injuries of the weight-bearing femoral condyle, trochlea, patella and tibial plateau.⁵

The ACI technique involves two separate surgical procedures: arthroscopy followed by an arthrotomy. The first procedure is a minimally invasive arthroscopic assessment of the knee joint performed as an outpatient. The area of defect is measured and articular cartilage is harvested from a non-weight-bearing surface for cartilage cell culturing. The biopsy is usually taken from the superior medial edge of the trochlea or the lateral aspect of the intercondylar notch if there is an overhanging patellar facet on the medial side.^{2,3} The cartilage biopsy is then cryo-preserved until the date of surgery is scheduled³. At that time, it is thawed and cultured to the appropriate number of cell vials necessary for surgery.^{2,3,8}

The second procedure is open ACI surgery performed at least 3-5 weeks after the biopsy is taken. The cartilage defect is debrided back to the subchondral bone with a rim of healthy cartilage. A template of the defect is made and a periosteal patch, usually from the proximal medial tibia distal to the pes anserine insertion, or a synthetic collagen patch is microsutured to the margins of the cartilage defect. The cultured cartilage cells are injected under the patch, which is then sutured shut and sealed with fibrin glue. The joint is then closed and the procedure is complete. The injected cells must grow inside the joint to form a hard cartilage tissue, generally a 9-12 month process, and will continue to mature until up to 24 months.^{2,3,8}

When a patient has a varus or valgus malalignment as well as a chondral injury, an osteotomy is often performed. An osteotomy can be performed prior to ACI surgery or concomitantly.² The purpose of an osteotomy is to decrease the forces occurring at the site of the chondral defect and balance the forces that occur at the knee joint.¹¹ The most common types of osteotomy include: tibial tubercle osteotomy, high tibial valgus osteotomy and distal femoral varus osteotomy. Anteromedialization of the tibial tubercle is used to unload a patellar defect and correct for maltracking.¹² High tibial osteotomies are performed when there are large defects on the weight bearing femoral condyle. Gillogly et al. have reported that 94% of their patients who

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had an ACI to the patella and/or trochlea also underwent anteromedialization of the tibial tubercle at the same time.¹¹

Good outcomes have been reported in patients at 2 to 9 year follow-ups.⁹ Autologous chondrocyte implantation of isolated femoral condyle defects were found to be highly effective in relieving symptoms and restoring knee function.⁹ Most patients in this group returned to athletic activities in 12 to 18 months. Patients with more complicated articular defects had variable outcomes, with 60% reporting improvement based on the Brittberg-Peterson functional assessment score.⁹ Overall, ACI “produces a durable and effective repair for as long as 9 years for full thickness chondral lesions”.⁹ ACI for the treatment of osteochondritis dissecans has been found to produce an integrated repair tissue with successful clinical results in more than 90% of patients.¹³

Rehabilitation after autologous chondrocyte implantation is individualized based on the size, depth and location of the lesion, repair tissue maturation, as well as the condition of the surrounding articular cartilage. The goal of rehabilitation is to protect the graft while promoting maturation of the newly implanted chondrocytes through a program that focuses on regaining full range of motion (ROM), progressive weight bearing, lower extremity strengthening, flexibility and proprioceptive training.⁸ Care must be taken to avoid compressive loading or shearing of the graft.¹⁴ Progression of rehabilitation is based on the three stages of healing including; proliferation, transition, and remodeling/maturation.

Stages of Healing:

Stage 1 (weeks 0-6): Proliferation: Rapid proliferation of spindle-shaped cells with the defect filled. Mostly type I collagen with early formation of colonies of chondrocytes forming type II collagen.²

Viscoelastic Arthroscopic Appearance: Filled, soft white tissue. Gel-like appearance.

Stage 2 (weeks 7-12): Transition: Matrix formation, mostly chondrocytes producing type II collagen and proteoglycans. Poor integration to underlying bone and cartilage.²

Viscoelastic Arthroscopic Appearance: Jelly-like firmness with “wave-like” motion when probed, not yet firm and integrated to underlying bone.²

Stage 3 (weeks 12-26): Remodeling: Ongoing remodeling of matrix with reorganization and quantity of type II collagen, with integration to bone and adjacent host cartilage. Large chain aggregates of proteoglycans are formed, with increased water content of cartilage.²

Viscoelastic Arthroscopic Appearance By 4-6 months after ACI the graft is firm, “indentable”, putty-like, but not “wave-like” when probed. Graft whiter than host cartilage, may demonstrate periosteal hypertrophy.²

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Stage 4 (weeks 26+) Maturation: Repair tissue usually reaches full maturation, resembling the surrounding tissue. Equal firmness to host cartilage 9-18 months after ACI.²

It is important to take into account the biomechanics of the knee and the site of the graft when designing the appropriate rehabilitation protocol after ACI surgery. When the knee is in full extension the anterior femoral condyles articulate with the middle aspect of the tibial plateau. As the knee flexes, the femoral condyles roll posteriorly and glide anteriorly increasing the contact between the posterior aspects of the femoral condyles with the posterior aspect of the tibial plateau. The patella glides inferiorly during knee flexion and superiorly with knee extension. When the knee is in full extension the patella lies proximal to the trochlea and at approximately 20 degrees of flexion the patella begins to make contact with the trochlea, entering from the lateral side. As knee flexion increases the patella is compressed against the femur.¹⁵ Maximal patellofemoral contact force occurs from 40-70 degrees of flexion.²

Immediate postoperative range of motion is important because it assists in providing nutrients to the healing tissues, decreases the likelihood of intra-articular adhesions and stimulates cellular orientation/chondrocyte maturation.^{2,16} On post-operative day 1 the continuous passive motion machine (CPM) is initiated as well as ROM of the knee. Studies have shown that continuous passive motion in the immediate post operative period stimulates free periosteal grafts in rabbits to produce hyaline articular cartilage; those that were immobilized demonstrated significant deterioration in the quality of the regenerated tissue.¹⁶

Patellar mobilization and cross friction massage are important in preventing tissue adhesions along the scar as well as the medial and lateral gutters of the knee. Impaired patellar mobility can lead to decreased knee ROM.

Progressive weight bearing is also important for stimulating cellular orientation/chondrocyte maturation while at the same time preventing graft overload as it matures. Protective weight bearing must be maintained for 6-12 weeks after surgery, depending on the graft site, to prevent the likelihood of periosteal overload and central degeneration or delamination of a weight bearing graft.² Graft sites are gradually loaded based on the above stages of tissue healing. Signs that the weight bearing may be progressing too rapidly include increased pain, swelling and/or clicking in the knee.

Procedures to repair articular cartilage can cause considerable effusion and pain. Cryotherapy, elevation and use of interferential stimulation can assist in reducing swelling and pain. Inhibition of the quadriceps muscles often occurs with pain and swelling of the knee and therefore neuromuscular electrical stimulation (NMES) and biofeedback are used for quadriceps muscle re-education.

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Isometric and gentle functional muscle exercises are initiated post-operatively to regain muscle tone and prevent atrophy.²

Indications for Treatment:

- Impaired ROM
- Impaired patellar mobility
- Lower extremity weakness
- Impaired function
- Impaired gait
- Pain
- Impaired balance/proprioception
- Impaired understanding of precautions: CPM, ROM, weight bearing status and use of brace

Contraindications / Precautions for Treatment:

- **Do not overload graft.-** Avoid twisting, rotational and shearing forces. Gradual progression of weight-bearing per protocol only. (See Table 2)
- Increased pain, swelling and/or clicking are signs that the patient may be progressing too quickly. Activity level should be modified if this occurs and the MD should be notified.
- Intraarticular adhesions with resultant stiffness may occur with large or multiple grafts. These adhesions are treated best with early (6-8 week after ACI) lysis of adhesions, graft assessment and manipulation. Closed manipulation is not often recommended because the adhesions can involve the graft surface and can result in graft delamination.¹⁷
- Incomplete periosteal graft incorporation to host cartilage and hypertrophic graft edge response are the most common problems after ACI. This usually occurs due to proliferative hypertrophic periosteal healing response between 4 and 7 months. Patients will present with a new onset of catching, pain and effusion.² The patient should be referred back to the doctor and activity levels decreased if this should occur. Some patients will require a 2nd look arthroscopy for periosteal hypertrophy of the graft.

In a 1 year short term follow up study it was found that using a collagen membrane, instead of a periosteal graft for an ACI has lower reoperation rate for hypertrophy. 25.7% of patients with a periosteal covered and only 5% of patients who had the collagen membrane covered ACI required reoperation for graft hypertrophy. 1 year failure rates were comparable between the two groups.¹⁸

- Depending on the graft site ROM may be limited.

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- Only passive knee extension during the first 6 weeks with trochlea or patella grafts.
- CPM 0-40 during first 3 weeks then ROM as tolerated with trochlea or patella grafts because maximal patellofemoral articulation occurs between 40 to 70 degrees.
- When a tibial tubercle osteotomy is performed in combination with an ACI, SLR/active knee extension is not permitted for the first 6 weeks. Only passive extension is allowed.
- Monitor for signs/ symptoms of infection, compartment syndrome, and/or DVT

Examination:

Medical History: Review patient's medical history questionnaire and medical history. Review any diagnostic imaging, operative notes, testing, or work-up.

History of Present Illness: Interview patient at the time of examination to review patient's history and any relevant information. Review operative notes noting graft site and whether or not an osteotomy was performed.

Social History: Review patient's home, work, recreational and social situations, previous level of functional activities and goals. Determine patient's understanding of surgical procedure, rehabilitation protocol and post-operative precautions.

Medications: Patient will likely be taking pain medication as prescribed by their surgeon. Patients are **NOT** to use nonsteroidal anti-inflammatories (NSAIDs) for at least 6-9 months after surgery because they can inhibit proteoglycan secretion affecting cartilage growth.¹⁹

Pain: Measure using Visual Analog Scale (VAS). Determine activities that may increase or decrease symptoms, location of symptoms, and irritability. Indicate on a body diagram the location of symptoms.

Visual Inspection: Attention to the presence of swelling, condition of incisions, signs of infection, compartment syndrome, joint deformity and patient's overall functional use of

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the knee. Inspect brace for proper alignment, fit and integrity of lock. Inpatient: Inspect fit of CPM and proper set up as well as Kendall foot pumps and cryocuff.

Lower Extremity Posture: Q-angle, hip anteversion/retroversion, knee varus/valgus or recurvatum, patella alta, baja or squinting, tibial torsion, foot pronation/supination.

Edema/ Atrophy: Typical circumference measurements of the knee joint are taken at mid patella, as well as 10-15 cm above and below.

ROM: Lower quarter screen focusing on knee flexion and extension. See Table 1 for ROM restrictions. **When tibial tubercle osteotomy is performed SLR/active knee extension is not permitted. For any patella or trochlea graft site only passive extension is allowed.**

Muscle Performance: Manual muscle testing of hip & ankle - all directions. Early post-operative knee strength will be assessed through visual inspection and palpation with special attention to the vastus medialis oblique muscle activity and density. Manual muscle testing of knee extension to be performed at subsequent re-evaluations when appropriate.

Patellar Mobility: Medial, lateral, superior, inferior.

Muscle Length: Hamstrings, iliotibial band, iliopsoas, gastrocnemius, soleus.

Gait: Patient will have protective weight bearing based on site of graft for approximately 12 weeks (See Table 1). Insure that the patient is maintaining correct weight bearing status and is safe with assistive devices.

Weight bearing as tolerated (WBAT) with crutches: Patella, trochlea, patella/trochlea graft sites.

Heel-toe touch down weight bearing (TDWB) with crutches: Tibia and femur, tibial plateau, weight bearing femoral condyle, weight bearing femoral condyle/patella, weight bearing femoral condyle /trochlea.

See Table 1 for brace information

Proprioception/Balance: Assess as appropriate in uninvolved leg, and in involved leg once patient is allowed to be full weight bearing. Measured by timing single leg stance (SLS).

Differential Diagnosis: None secondary to post-operative status unless patient has any co-morbid issues and/or post-operative complications that need to be considered.

Rehabilitation:

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There are four phases of rehabilitation based on the four stages of healing:

Phase 1: Weeks 0-6

Phase 2: Weeks 7-12

Phase 3: Weeks 12-26

Phase 4: Weeks 26+

Phase 1 : Acute (Inpatient days 0-4)

Physical therapy begins the day after surgery- Post-operative day 1 (POD1)

Impairments:

- Pain
- Edema
- Impaired patellar mobility
- Impaired knee ROM
- Impaired muscle performance of hip and knee
- Impaired function-Bed mobility, transfers, ADL/IADL
- Impaired gait

Goals:

- 1) ROM. Increase tibial-femoral and patellofemoral mobility
- 2) Decrease pain and swelling
- 3) Prevent ACI graft over-load
- 4) Encourage muscle tone. Restore quadriceps control
- 5) Independence with home exercise program

The CPM is initiated POD1 and is increased depending on the defect location (See table 1). Begin 0-30 degrees POD1 then increase 10 degrees/day or as tolerated for weight bearing femoral condyle, tibial plateau, tibia and femur graft sites. **For any patella or trochlea graft site CPM 0-40 only for first 3 weeks then increase to full as tolerated.** The CPM is used approximately 6-8 hours daily for the initial 6 weeks to enhance the quality of repair tissue and increase repair tissue fill.¹⁶ CPM for defects of the trochlea and patella is limited to 0-40 degrees only for the first 3 weeks because maximal patellofemoral contact forces occur at 40-70 degrees. Therefore, greater ROM is not recommended.²

The physical therapist will instruct the patient in a home exercise program and initial ROM on POD 1 based on the specific type of ACI surgery (See Table 1). Patients will have an epidural until POD2 and therefore will only perform ROM and other exercises while in supine or at the edge of the bed on POD1.

On POD 1 the physical therapist will initiate AROM and AAROM of the knee. ROM will vary depending of the graft site. (See Table 1) When a tibial tubercle

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osteotomy is performed SLR/active knee extension is not permitted. For any patella or trochlea graft site only passive extension is allowed.

Immediately after surgery the patient will be placed in a knee immobilizer, which can be use when not in the CPM or performing exercises. On POD 2 the patient will be fitted with a hinged knee brace (Bledsoe brace) to be worn during ambulation until further notified by their doctor. (Patients with a tibial plateau graft will receive a prescription from their doctor in order to obtain an unloading brace from an outside vender once discharged from the hospital).

Patients will begin standing/walking with bilateral upper extremity assistive devices on POD2 (after the epidural is stopped and full LE motor control has returned). Cryotherapy, Kendall foot pumps and compression stockings are used for swelling, pain control and prevention of DVT.

Multi-directional patellar mobilization should begin immediately after surgery.

The patient will be discharged home with a CPM machine as well as a home exercise program.

Electrical stimulation for VMO/ quadriceps muscle re-education is encouraged early after surgery if indicated.

Weight bearing, CPM and ROM will depend on the graft site. (See Table 1)

Home discharge criteria:

- 1) Safe transfers
- 2) Safe ambulation with bilateral upper extremity assistive devices on level and stairs
- 3) Good understanding of precautions, weight bearing status, ROM, use of CPM, use of brace and home exercise program
- 4) Healthy appearing wound
- 5) Afebrile
- 6) Good pain control

Phase 1: Sub-Acute (Outpatient): (Weeks 1-6)

The patient will be seen in an outpatient facility or by a home physical therapist after being discharged from the hospital.

Impairments:

- Edema
- Pain
- Impaired patellar mobility
- Impaired knee ROM
- Impaired muscle performance of hip and knee
- Impaired function- ADL/IADL
- Impaired gait

Goals:

- Increase tibial-femoral and patella-femoral mobility
- Decreased pain and swelling

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- Restore quadriceps control
- Full knee extension
- Week 3: at least 90 degrees of flexion
- Week 6: at least 110 degrees of flexion
- Independence with home exercise program
-

No progression to stage 2 until MD clears patient at 6 weeks post- op

Treatment Plan:

- Begin use of CPM POD1 for 6-8 hours/day for 6weeks. Begin 0-30 degrees POD1 then increase 10 degrees/day as tolerated. **EXCEPT FOR PATELLA OR TROCHLEA GRAFT SITES- CPM is limited to 0-40 degrees only for first 3 weeks then increase to full as tolerated.**
- Protective weight bearing with use of brace (table1)
- Isometric exercises, ROM (table 1), Multi-directional patellar mobilization
- E-Stim for VMO/ quadriceps muscle re-education
- Soft tissue mobilization/deep friction to hamstring insertions, peripatellar region, medial/lateral gutters and scar.
- Cryotherapy for edema control
- Compression stockings/TEDS for edema control and DVT prevention
-

Phase 2: (Weeks 7-12):

Impairments:

- Edema
- Pain
- Impaired patellar mobility
- Impaired knee ROM
- Impaired muscle performance of hip and knee
- Impaired gait
- Impaired balance reactions
- Impaired function- ADL/IADL

Goals:

- Increase tibial-femoral and patella-femoral mobility
- Restore quadriceps control
- Full knee ROM by 12 weeks

Treatment Plan:

- Discontinue CPM

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- Continue with E-Stim for VMO/ quadriceps muscle re-education if indicated
- May begin gentle A/AAROM extension for all graft sites if not previously allowed
- Multi-directional patellar mobilization
- Partial graduated weight bearing to full weight bearing by 12 weeks (See Table 2)
- Progression of exercises per protocols
- Functional muscle usage, stationary bicycle, with progression to treadmill
- Cryotherapy for edema control

No progression to stage 3 until MD clears patient at 12 weeks post- op

Phase 3 (Weeks 12-26):

Impairments:

- Edema
- Pain
- Impaired patellar mobility
- Impaired knee ROM
- Impaired muscle performance of hip and knee
- Impaired gait
- Impaired balance reactions
- Impaired function-ADL/IADL

Goals

- Discontinue assistive device.
- Normal gait pattern
- Improve muscular strength and endurance
- Return to normal ADL's/IADL's
- Independence with home exercise program

Treatment Plan:

- Discontinue assistive devices 4-5 months post op if free of pain, no catching or swelling and patient demonstrates proper gait mechanics.
- Distance walking, resistance walking

Phase 4 (Weeks 26+):

Impairments:

- Impaired muscle performance of hip and knee
- Impaired balance reactions
- Impaired functional activities

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Goals

- Gradual return to functional activities and sports

Functional activities (depending on graft site)

- Skating, in-line skating, and cycling are permitted at 6 months
- Running and aerobics may be performed at 12 month
- Pivoting sports such as tennis, basketball, football, golf and baseball may begin at 12-18 months depending on graft site and once patient cleared by MD

Table 1 ROM and CPM restrictions phase 1

Graft Sites	Weight Bearing	ROM	CPM	Brace
Weight bearing femoral condyle	Heel-toe TDWB	Full AROM, gentle AAROM	As tolerated	Knee immobilizer with ambulation, until good quad control/SLR (~3-6 weeks)
Weight bearing femoral condyle/Patella	Heel-toe TDWB	Gentle AROM flexion as tolerated, Passive extension only	0-40 for first 3 weeks then increase as tolerated	Hinged knee brace locked in full extension for transfers and ambulation
Weight bearing femoral condyle/Trochlea	Heel-toe TDWB	Gentle AROM flexion as tolerated, Passive extension only	0-40 for first 3 weeks then increase as tolerated	Hinged knee brace locked in full extension for transfers and ambulation
Patella	Weight bearing as tolerated with bilateral upper extremity device	Gentle AROM flexion as tolerated, Passive extension only	0-40 for first 3 weeks then increase as tolerated	Hinged knee brace locked in full extension for transfers and ambulation
Trochlea	Weight bearing as tolerated with bilateral upper extremity device	Gentle AROM flexion as tolerated, Passive extension only	0-40 for first 3 weeks then increase as tolerated	Hinged knee brace locked in full extension for transfers and ambulation
Patella/Trochlea	Weight bearing as tolerated with bilateral upper extremity device	Gentle AROM flexion as tolerated, Passive extension only	0-40 for first 3 weeks then increase as tolerated	Hinged knee brace locked in full extension for transfers and ambulation
Tibial Plateau	Heel-toe TDWB	Full AROM, gentle AAROM	As tolerated	Unloading brace to be worn at all times for at least 6-9 months after surgery
Tibia and femur	Heel-toe TDWB	Full AROM, gentle AAROM	As tolerated	Unloading brace to be worn at all times for at least 6-9 months after surgery

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With multiple graft sites use most conservative/restrictive guidelines

When tibial tubercle osteotomy is performed SLR/active knee extension is not permitted

Table 2 Weight Bearing Progression

Graft site	Weeks 7&8	Weeks 9&10	Weeks 11&12	Weeks 13+
Weight bearing femoral condyle	PWB 1/3 body weight	PWB 2/3 body weight	FWB with crutches	Crutch, cane or no device as tolerated
Weight bearing femoral condyle/Patella	PWB 1/3 body weight	PWB 2/3 body weight	FWB with crutches	Crutch, cane or no device as tolerated
Weight bearing femoral condyle/Trochlea	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed
Patella	Full weight bearing as tolerated	Full weight bearing as tolerated	Full weight bearing as tolerated	Full weight bearing as tolerated
Trochlea	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed
Patella/Trochlea	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed	Full weight bearing as tolerated with crutch or cane as needed
Tibial Plateau	PWB 1/3 body weight	PWB 2/3 body weight	FWB with crutches	Crutch, cane or no device as tolerated
Tibia and femur	PWB 1/3 body weight	PWB 2/3 body weight	FWB with crutches	Crutch, cane or no device as tolerated

If the patient experiences pain when progressing to the next stage of weight bearing, revert back to the previous stage for an additional week.

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Prognosis: Full return to all functional activities including sports as determined by MD.

Treatment Planning

Established Pathway ___ Yes, see attached. X No

Established Protocol X Yes, see attached. ___ No

Frequency & Duration: 2-3 times for week for 12-15 weeks

Patient / family education: Handouts on protocol including exercises and precautions.

Re-evaluation / assessment

Standard Time Frame: At least once every 30 days

Other Possible Triggers: Increased pain, swelling or catching, Signs of infection, DVT, or compartment syndrome.

Discharge Planning

Commonly expected outcomes at discharge: Full knee ROM, normal gait pattern, return to previous levels of functional activities and independent with home exercise program.

Patient's discharge instructions: Continue strengthening, stretching, and balance training through HEP. Return to sports activities as per MD orders.

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Reference List

1. Saidoff DC, McDonough AL. *Critical Pathways in Therapeutic Intervention*. 1st ed. St. Louis, Missouri: Mosby,inc; 2002.
2. Minas T, Peterson L. Autologous chondrocyte transplantation. *Operative Techniques in Sports Medicine*. 2000;8:144-157.
3. King PJ, Bryant T, Minas T. Autologous chondrocyte implantation for chondral defects of the knee: Indications and technique. *J Knee Surg*. 2002;15:177-184.
4. Brittberg M, Lindahl A, Nilsson A, Ohlsson C, Isaksson O, Peterson L. Treatment of deep cartilage defects in the knee with autologous chondrocyte transplantation. *N Engl J Med*. 1994;331:889-895.
5. Minas T, Nehrer S. Current concepts in the treatment of articular cartilage defects. [review] [41 refs]. *Orthopedics*. 1997;20:525-538.
6. Briggs TW, Mahroof S, David LA, Flannelly J, Pringle J, Bayliss M. Histological evaluation of chondral defects after autologous chondrocyte implantation of the knee. *Journal of Bone & Joint Surgery - British Volume*. 2003;85:1077-1083.
7. Akeson WH, Bugbee W, Chu C, Giurea A. Differences in mesenchymal tissue repair. *Clin Orthop*. Oct 2001;391 supplement:S124-S141.
8. Gillogly SD, Voight M, Blackburn T. Treatment of articular cartilage defects of the knee with autologous chondrocyte implantation. [review] [64 refs]. *Journal of Orthopaedic & Sports Physical Therapy*. 1998;28:241-251.
9. Peterson L, Minas T, Brittberg M, Nilsson A, Sjogren-Jansson E, Lindahl A. Two- to 9-year outcome after autologous chondrocyte transplantation of the knee. *Clin Orthop Relat Res*. 2000;(374):212-234.
10. Genzyme Corporation. Carticel for Implantation. Available at: www.carticel.com. Accessed 12/06, 2006.

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11. Gillogly SD, Myers TH, Reinold MM. Treatment of full-thickness chondral defects in the knee with autologous chondrocyte implantation. *Journal of Orthopaedic & Sports Physical Therapy*. 2006;36:751-764.
12. Minas T, Bryant T. The role of autologous chondrocyte implantation in the patellofemoral joint. *Clinical Orthopaedics & Related Research*. 2005:30-39.
13. Peterson L, Minas T, Brittberg M, Lindahl A. Treatment of osteochondritis dissecans of the knee with autologous chondrocyte transplantation: Results at two to ten years. *J Bone Joint Surg Am*. 2003;85-A Suppl 2:17-24.
14. Irrgang JJ, Pezzullo D. Rehabilitation following surgical procedures to address articular cartilage lesions in the knee. *J Orthop Sports Phys Ther*. 1998;28:232-240.
15. Hungerford DS, Barry M. Biomechanics of the patellofemoral joint. *Clinical Orthopaedics & Related Research*. 1979:9-15.
16. O'Driscoll SW, Keeley FW, Salter RB. Durability of regenerated articular cartilage produced by free autogenous periosteal grafts in major full-thickness defects in joint surfaces under the influence of continuous passive motion. A follow-up report at one year. *Journal of Bone & Joint Surgery - American Volume*. 1988;70:595-606.
17. Minas T. Autologous chondrocyte implantation for focal chondral defects of the knee. *Clinical Orthopaedics & Related Research*. 2001:S349-61.
18. Gomoll A, Probst C, Farr J, Cole B, Minas T. Use of a type I/III bilayer collagen membrane decreases reoperation rates for symptomatic hypertrophy after autologous chondrocyte implantation. *American Journal of Sports Medicine*. 2009;37:20S-23S.
19. Suh J, Aroen A, Muzzonigro T, Disilvestro M, Fu F. Injury and repair articular cartilage; related scientific issues. *Operative Techniques in Orthopaedics*. 1997;Vol 7:270-278.

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