Matrix-Induced Autologous Chondrocyte Implantation (MACI®) for Repair of Articular Cartilage Defects
Disclosure/No Medical Advice

• The speaker is a paid consultant of Vericel Corporation

• The information contained in the following material does not constitute medical advice. The information regarding surgical techniques and rehabilitation are general guidelines. Individual results will vary among patients and depend on many factors. A patient's healthcare provider should consider the circumstances of each patient when considering MACI
Indication

MACI® is an autologous cellularized scaffold product indicated for the repair of symptomatic, single or multiple full-thickness cartilage defects of the knee with or without bone involvement in adults.

Dosage and Administration

For autologous implantation only

- Contact Vericel at 1-800-453-6948 or www.MACI.com regarding training materials for surgical implantation of MACI
- The amount of MACI implanted depends on the size (surface area in cm²) of the cartilage defect
- MACI should be trimmed to the size and shape of the defect and implanted with the cell-side down
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, cont’d

- 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 (≥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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Articular Cartilage Defects of the Knee

Acute injury\(^1,2\)  
\[\downarrow\]  
Tissue necrosis  
\[\downarrow\]  
Limited regenerative capacity for cartilage  
\[\downarrow\]  
Repetitive loading  

Retrospective studies of knee arthroscopies have found\(^3-5\):

\[\sim 60\% \quad \text{had chondral or osteochondral lesions} \]

\[6\%-7\% \quad \text{had full-thickness defects >2 cm}^2\]

Mean annual incidence of surgical procedures for cartilage defects has been estimated at

90 per 10,000 Patients\(^6\)

Historical Timeline of Autologous Chondrocyte Implantation (ACI)

ACI uses cultured chondrocytes to repair deep cartilage defects of the knee

First report of ACI in humans using a periosteal patch

First clinical report of matrix-induced autologous chondrocyte implantation (MACI®)

Carticel® becomes first FDA-approved biologics license application for cell therapy

MACI is FDA approved for repair of symptomatic, full-thickness cartilage defects of the knee

Results of SUMMIT, a randomized controlled clinical trial comparing MACI and microfracture, are published

MACI is approved as an advanced therapy medicinal product by the European Medicines Agency (EMA)

Carticel becomes first FDA-approved biologics license application for cell therapy

ACI using a collagen patch is reported

Results of STAR, a prospective clinical trial to examine efficacy, durability, and safety of Carticel ACI, are released and FDA approves expanded label

MACI Overview

1. Defect assessment and cartilage biopsy

2. Cells are isolated and expanded (~4 weeks)

3. Cells are seeded on a collagen membrane (2-4 days)

4. Chondrocyte viability and screening assays

5. Cell-seeded membrane is implanted via an arthrotomy with fibrin sealant

Average time from biopsy to implantation is 6 weeks

MACI Procedure:

1 Cartilage Biopsy: Three Step Process

I MACI eligibility is confirmed via arthroscopy

- At least 1 Outerbridge grade III-IV focal cartilage defect in the knee
- Defect ≥2 cm
- Stable knee
- Intact or partial meniscus (≥50% of functional meniscus remaining)

II Cartilage tissue collected

200-300 mg healthy cartilage tissue collected from non–load-bearing area of the knee

Recommended sites include: Lateral intercondylar notch and superior medial or lateral trochlear ridge

III Biopsy tissue is packed and shipped to Vericel using supplied transport kit

MACI Procedure: Chondrocyte Propagation and Membrane Seeding

1. Chondrocytes are isolated from biopsy tissue and propagated in vitro for approximately 4 weeks.\(^1\)

2. Cells are then seeded on a type I/III collagen membrane before being shipped to the surgeon in a sterile, sealed polystyrene dish.\(^2\)

Each MACI implant is released at a density of at least 500,000 cells per cm\(^2\).

Properties of the ACI-Maix\(^\text{TM}\) Membrane\(^1\)

- **Smooth surface**
  - Smaller pore size inhibits cell migration
  - Oriented toward the joint cavity

- **Rough surface**
  - Larger pore size supports chondrocyte adherence
  - Oriented toward the subchondral bone

Chondrocytes attach to the rough surface of the membrane via cytoplasmic projections.\(^3\)


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Prior to shipment, each MACI implant must pass rigorous release assays for:

- Sterility
- Endotoxins
- Viability of chondrocytes
- Identification of cells
- Potency
- Mycoplasma
- Uniform cell density
- Minimum cell number
MACI is implanted during an arthrotomy

1. Defect is assessed and debrided
MACI Procedure: Implantation

MACI is implanted during an arthrotomy

1. Defect is assessed and debrided

2. Template is sized and shaped to match defect
   MACI implant is cut according to template
MACI Procedure: Implantation

MACI is implanted during an arthrotomy

1. Defect is assessed and debrided

2. Template is sized and shaped to match defect
   MACI implant is cut according to template

3. Thin layer of Fibrin sealant is applied to empty defect
   Membrane is placed into the defect, with the cells facing the bone bed
   Fibrin is then added to the surrounding edge
MACI Procedure: Implantation

MACI is implanted during an arthrotomy

1. Defect is assessed and debrided

2. Template is sized and shaped to match defect
   MACI implant is cut according to template

3. Fibrin sealant is applied to empty defect
   Membrane is placed on the defect, with the cells facing the bone bed
   Fibrin is then added to the surrounding edge

4. Gentle pressure is applied until the membrane is secured
   After fibrin has set, knee is fully extended and flexed several times
### Rehabilitation Overview

<table>
<thead>
<tr>
<th>Continuous Passive Motion</th>
<th>Begin 12-24 hours after surgery, continue for 6 hours per day for 6 weeks</th>
</tr>
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<tbody>
<tr>
<td>Weight Bearing</td>
<td>Gradual progression from touchdown for 2 weeks to full weight at 8 weeks, as tolerated by the patient</td>
</tr>
<tr>
<td>Range of Motion</td>
<td>0°-90° for first week; increase by 10° per week to 135° Stationary bike at 4 weeks</td>
</tr>
<tr>
<td>Strengthening</td>
<td>Quadriceps strength is restored initially followed by CORE lower extremities Elliptical trainer at 2-3 months</td>
</tr>
<tr>
<td>Impact Loading</td>
<td>Low impact 5-6 months; jogging 6-7 months Return to sports at 12-18 months</td>
</tr>
<tr>
<td>Special Considerations</td>
<td>Trochlea implants: no open chain or shear loading for first 3 months Combined procedures (eg, ACL repair): follow ACI rehab first</td>
</tr>
</tbody>
</table>

Data on File. Vericel Corporation.
Key Features of MACI

At the time of implantation, **viable cells are distributed** throughout the MACI implant\(^1\)

Cells seeded on the MACI implant **attach to fibers and re-differentiate to their chondrocytic phenotype**\(^2\)

The use of a smaller arthrotomy with fibrin glue enables **less invasive and shorter** implantation surgeries (as compared to second-generation ACI)\(^3\)

Following implantation, cultured chondrocytes migrate through the **fibrin glue, which promotes cell proliferation**\(^2,4\)

- Cartilage repair tissue has been observed by 21 days post-surgery\(^2\)
- By 6-8 months, **chondrocytes produce extracellular matrix; graft begins to firm**

An **enhanced rehabilitation program** has been used with MACI\(^5\)

Patients can return to full weight bearing at 8 weeks post-surgery, compared with 11 weeks in a traditional rehabilitation program

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### The MACI Patient

#### 18-55 Years of Age¹-³:
- Joint pain that matches cartilage defect
- Functional activity impairment
- Compromised activities of daily living
- Comorbidities have been evaluated

#### Defect Size and Depth¹,³-⁴,⁶:
- Surface area ≥2 cm²
- <6 mm in depth into bone for cells only
- >6 mm of bone involvement, a sandwich technique is recommended

#### Demand Match Approach³:
- Lesion size vs level of activity
- Outcome provides meaningful change for the patient
- Active: sports and recreational activities
- Job expectations

#### Patient Factors¹-³,⁵-⁷:
- Mental outlook
- Non-smoker
- No baseline narcotics
- Realistic post-op expectations
- Willing to undergo prolonged absence of impact loading (10-12 months)
- Not clinically obese (>35 BMI)

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SUMMIT Clinical Study
Chapter 2
SUMMIT Trial Design

Eligibility criteria
- 18-55 years of age
- ≥1 symptomatic cartilage defect
  - Outerbridge grade III or IV defects of the MFC, LFC, and/or trochlea; ≥3 cm²
  - KOOS pain <55
- OCD lesions if no bone graft required
- Intact or partial (≥50%) meniscus
  - Meniscal repair or resection allowed before/during cartilage repair

KOOS, Knee Injury and Osteoarthritis Outcome Score; LFC, lateral femoral condyle; MFC, medial femoral condyle; MFX, microfracture; MRI, magnetic resonance imaging; OCD, osteochondritis dissecans
## SUMMIT Endpoints

<table>
<thead>
<tr>
<th>ENDPOINT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Co-primary</strong></td>
<td>Change from baseline in KOOS pain and function subscores at 24 months</td>
</tr>
<tr>
<td></td>
<td>• Histology (ICRS II) at 24 months</td>
</tr>
<tr>
<td></td>
<td>• Assessment of defect fill by MRI at 24 months</td>
</tr>
<tr>
<td></td>
<td>• Responder rate(^{a}) at 24 months</td>
</tr>
<tr>
<td></td>
<td>• Treatment failure rate(^{b}) at 24 months</td>
</tr>
<tr>
<td></td>
<td>• Other KOOS subscales (activities of daily living, knee-related quality of life, and other symptoms) at 24 months</td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>• At Weeks 24, 36, 52, and 78:</td>
</tr>
<tr>
<td></td>
<td>• Change in all KOOS subscales</td>
</tr>
<tr>
<td></td>
<td>• Response rate(^{a})</td>
</tr>
<tr>
<td></td>
<td>• Treatment failure</td>
</tr>
<tr>
<td></td>
<td>• Other clinical assessments: Modified Cincinnati Knee Rating System and IKDC</td>
</tr>
<tr>
<td></td>
<td>• Quality of life assessments: SF-12 and EQ-5D at 24 and 48 months</td>
</tr>
<tr>
<td></td>
<td>• Macroscopic ICRS “Cartilage Repair Assessment” at 48 months</td>
</tr>
<tr>
<td><strong>Tertiary</strong></td>
<td>• TEAEs</td>
</tr>
<tr>
<td></td>
<td>• Serious adverse events</td>
</tr>
<tr>
<td></td>
<td>• Subsequent surgical procedures</td>
</tr>
</tbody>
</table>

\(^{a}\)Defined as the percentage of patients who experienced a ≥10-point improvement in KOOS pain and function subscales after MACI implant or microfracture.

\(^{b}\)Defined as the percentage of patients who, at any time after week 24, had a patient and physician global assessment result that was the same or worse than at baseline, a <10% improvement in the KOOS pain subscale, or physician-diagnosed failure.

EQ-5D, European Quality of Life 5 dimensions questionnaire; ICRS, International Cartilage Repair Society; KOOS, Knee Injury and Osteoarthritis Outcome Score; MRI, magnetic resonance imaging; SF-12, 12-Item Short Form Health Survey; TEAE, treatment-emergent adverse event

Key Features of the SUMMIT Trial

To date, the **largest prospective randomized controlled** trial of knee cartilage repair with the **highest power to show clinical difference**

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**Designed in accordance with FDA guidance on trials for knee cartilage repair, including**¹,²:

- Choice of microfracture as comparator
- Selection of KOOS pain and function as co-primary endpoints

**Additional features**¹:

- Multi-center study design allowed for assessment of consistency of outcomes
- Conducted according to Good Clinical Practice (GCP) and principles of the Declaration of Helsinki
- All surgeons were trained on standardized surgical procedures
- Standardized rehabilitation procedures were followed

**Patient Disposition (2 Years)**

- **Patients screened**
  - n=189

- **Patients randomized**
  - n=144
    - **Elected not to participate**
      - N = 45

- **MACI**
  - n=72
    - **Completed**
      - n=70
    - **Withdrawn**
      - n=2
    - **Primary reason for withdrawal**
      - Adverse events: n=1
      - Wish to withdraw: n=1
      - Lack of efficiency: n=0

- **MFX**
  - n=72
    - **Completed**
      - n=67
    - **Withdrawn**
      - n=5
    - **Primary reason for withdrawal**
      - Adverse events: n=1
      - Wish to withdraw: n=1
      - Lack of efficiency: n=3

MFX, microfracture

Baseline Patient Characteristics

There were no statistical differences between the MACI and MFX demographics

<table>
<thead>
<tr>
<th>Patient Demographic</th>
<th>MACI (n=72)</th>
<th>MFX (n=72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>34.8 (9.2)</td>
<td>32.9 (8.8)</td>
</tr>
<tr>
<td>Patients &lt;40 y, n (%)</td>
<td>24 (33.3)</td>
<td>17 (23.6)</td>
</tr>
<tr>
<td>Male, %</td>
<td>62.5</td>
<td>66.7</td>
</tr>
<tr>
<td>BMI, mean (SD), kg/m²</td>
<td>26.2 (4.3)</td>
<td>26.4 (4.0)</td>
</tr>
<tr>
<td>Duration of symptoms, mean (range), y</td>
<td>5.8 (0.05-28.0)</td>
<td>3.7 (0.1-15.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lesion Characteristic</th>
<th>MACI (n=72)</th>
<th>MFX (n=72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index lesion size, median (range), cm²</td>
<td>4.0 (3.0-20.0)</td>
<td>4.0 (3.0-11.2)</td>
</tr>
<tr>
<td>Location, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFC</td>
<td>54 (75.0)</td>
<td>53 (73.6)</td>
</tr>
<tr>
<td>LFC</td>
<td>13 (18.1)</td>
<td>15 (20.8)</td>
</tr>
<tr>
<td>Trochlea</td>
<td>5 (6.9)</td>
<td>4 (5.6)</td>
</tr>
<tr>
<td>Etiology, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute trauma</td>
<td>33 (45.8)</td>
<td>45 (62.5)</td>
</tr>
<tr>
<td>Chronic degeneration</td>
<td>18 (25.0)</td>
<td>9 (12.5)</td>
</tr>
<tr>
<td>Osteochondritis dissecans</td>
<td>8 (11.1)</td>
<td>12 (16.7)</td>
</tr>
<tr>
<td>Other*</td>
<td>13 (18.1)</td>
<td>6 (8.3)</td>
</tr>
<tr>
<td>Outerbridge grade, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>21 (29.2)</td>
<td>15 (20.8)</td>
</tr>
<tr>
<td>IV</td>
<td>51 (70.8)</td>
<td>57 (79.2)</td>
</tr>
</tbody>
</table>

*Other included degeneration after trauma 22 years ago, subchondral bone cyst, anterior cruciate ligament repair, knee pain, and unknown.
BMI, body mass index; LFC, lateral femoral condyle; MFC, medial femoral condyle; MFX, microfracture; SD, standard deviation; y, year

KOOS Pain and Function Subscales

Two years after treatment, the change from baseline in KOOS pain and function subscores was significantly higher for **MACI vs MFX** (*P*<0.001) with the co-primary endpoint.

KOOS Pain Subscale

KOOS Function Subscale

KOOS, Knee Injury and Osteoarthritis Outcome Score; MFX, microfracture

KOOS Pain and Function Subscales: Changes Over Time

In a post-hoc analysis, the improvement with MACI over MFX in KOOS pain and function subscores was observed early in the treatment.

This analysis was not a part of the FDA's approval of MACI.
The proportion of patients who responded to treatment was higher with MACI when compared with MFX at 2 years (secondary endpoint).

Response defined as ≥10-point improvement in both pain and function subscores.

KOOS, Knee Injury and Osteoarthritis Outcome Score; MFX, microfracture

Predictors of Response Rate by Lesion Characteristics

In a post-hoc subgroup analysis, responder rates were higher with MACI vs MFX in patients with lesions >4 cm², MFC lesions, and lesions that were not OCD.

Response defined as ≥10-point improvement in both pain and function subscores.

KOOS, Knee Injury and Osteoarthritis Outcome Score; MFC, median femoral condyle; MFX, microfracture; OCD, osteochondritis dissecans

This analysis was not a part of the FDA’s approval of MACI.


### Treatment-Emergent Adverse Events (TEAEs)

- Incidence of TEAEs related to study treatment was comparable for MACI (34.7%) and MFX (38.9%)\(^1\)
- Serious TEAEs occurred in 26% of the MFX treatment group vs 15% of the MACI treatment group\(^1\)
- The proportion of patients with at least 1 subsequent surgical procedure on the knee joint was comparable between treatment groups (8.3% in the MACI group and 9.7% in the MFX group)\(^2\)

<table>
<thead>
<tr>
<th>Adverse Reactions in ≥5% of Patients, n (%)</th>
<th>MACI (n=72)</th>
<th>MFX (n=72)</th>
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</thead>
<tbody>
<tr>
<td><strong>Musculoskeletal and connective tissue disorders</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthralgia</td>
<td>37 (51.4)</td>
<td>46 (63.9)</td>
</tr>
<tr>
<td>Back pain</td>
<td>8 (11.1)</td>
<td>7 (9.7)</td>
</tr>
<tr>
<td>Joint swelling</td>
<td>7 (9.7)</td>
<td>4 (5.6)</td>
</tr>
<tr>
<td>Joint effusion</td>
<td>5 (6.9)</td>
<td>4 (5.6)</td>
</tr>
<tr>
<td><strong>Injury, poisoning, and procedural complications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cartilage injury</td>
<td>3 (4.2)</td>
<td>9 (12.5)</td>
</tr>
<tr>
<td>Ligament sprain</td>
<td>3 (4.2)</td>
<td>5 (6.9)</td>
</tr>
<tr>
<td>Procedural pain</td>
<td>3 (4.2)</td>
<td>4 (5.6)</td>
</tr>
<tr>
<td><strong>General disorders and administration site conditions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment failure</td>
<td>1 (1.4)</td>
<td>4 (5.6)</td>
</tr>
</tbody>
</table>

MFX, microfracture; TEAE, treatment-emergent adverse event

At 2 years, KOOS pain and function had improved from baseline in both treatment groups; the improvement was statistically significantly ($P=0.001$) greater in the MACI group compared with the MFX group.

MACI also led to greater improvement in the following KOOS subscales:

- **Activities of daily living** ($P<0.001$)
- **Knee-related quality of life** ($P=0.029$)
- **Other symptoms** ($P<0.001$)

KOOS response rate was greater for MACI ($P=0.016$)

Safety profiles were similar between both treatment groups

- The most common TEAEs associated with MACI (incidence >10%) were arthralgia, headache, nasopharyngitis, and back pain

Difference in Co-Primary Endpoints of KOOS Pain and Function Maintained Over 5 Years in a Volunteer Extension Study

Significant improvement with MACI vs MFX at 36 weeks was maintained to 5 years
MACI Overview

1. Defect assessment and cartilage biopsy

2. Cells are isolated and expanded (~4 weeks)

3. Cells are seeded on a collagen membrane (2-4 days)

4. Chondrocyte viability and screening assays

5. Cell-seeded membrane is implanted via an arthrotomy with fibrin sealant

Average time from biopsy to implantation is 6 weeks
Patients who are candidates for MACI may undergo arthroscopy for defect assessment and cartilage collection\(^1\)\(^-\)\(^5\)

**18-55 Years of Age:**
- Joint pain that matches cartilage defect
- Functional activity impairment
  - Compromised activities of daily living
- Comorbidities have been evaluated

**Demand Match Approach:**
- Lesion size vs level of activity
- Outcome provides meaningful change for the patient
- Active: sports and recreational activities
- Job expectations

**Patient Factors:**
- Mental outlook
- Non-smoker
- No baseline narcotics
- Realistic post-op expectations
- Not clinically obese (>35 BMI)

---

Defect Assessment and Cartilage Biopsy

1. Confirm eligibility for MACI
2. Address all comorbidities
3. Select biopsy site
4. Harvest the biopsy
5. Prepare biopsy for shipment
Defect Assessment and Cartilage Biopsy

1. **Confirm eligibility for MACI via arthroscopy**

   1. Use the tip of a graduated arthroscopic hook to examine the defect
      - Contained vs uncontained
      - Unstable or undermining cartilage
      - Bone loss and quality of subchondral bone

   2. Calculate defect dimensions and bony involvement
      - Surface area ≥2 cm²
      - Not osteoarthritic (bipolar changes)
      - Bony involvement
        - <6 mm in depth into bone

   *Optional: Assess bone marginal viability (AVN) and bone marrow lesions via MRI*

Using probe to assess chondropenia

*If total size of all defects is >16.5 cm², 2 MACI implants should be ordered*
Defect Assessment and Cartilage Biopsy

Address all comorbidities before or concomitantly\textsuperscript{1,2}

- **Malalignment**
  - *The most important aspect of cartilage repair*
  - ✓ Coronal plane (varus/valgus)
  - ✓ Axial plane (femoral anteversion/tibial torsion)
  - ✓ Sagittal plane (tibial slope/recurvatum)

- **Meniscal deficiency**
- **Ligamentous deficiency**
- **Subchondral bone**
- **Synovial fluid**
- **Soft tissues**

Select biopsy site

Select a non-load-bearing area of the knee

- Superior medial trochlear ridge
- Lateral trochlea
- Intercondylar notch

Biopsy site should be >3 mm from the synovial junction zone
4 Harvest the biopsy

• Use a sharp-edged oval angulated curette
• Penetrate the cartilage to the subchondral bone plate
Defect Assessment and Cartilage Biopsy

4. Harvest the biopsy

- Use a sharp-edged oval angulated curette
- Penetrate the cartilage to the subchondral bone plate
- Pull the curette tangentially in slight side-to-side rotations
  - Leave stalked specimen to avoid biopsy loss into the synovial fluid
4 Harvest the biopsy

- Use a sharp-edged oval angulated curette
- Penetrate the cartilage to the subchondral bone plate
- Pull the curette tangentially in slight side-to-side rotations
  - Leave stalked specimen to avoid biopsy loss into the synovial fluid
- Complete harvest with a non-toothed arthroscopic grasper
  - Specimen should be ~200 mg
- Leaving intact peripheral rim will enhance regeneration of the biopsy site
Defect Assessment and Cartilage Biopsy

5 Prepare biopsy for shipment

• Place the specimen into the transport medium in the provided biopsy tube
  • Seal cap tightly

Note: Biopsy tube exterior is not sterile

• A circulating nurse should hold the exterior of the tube away from the sterile field
• Surgical team should not directly contact the tube exterior and rim
Prepare biopsy for shipment

- Place the specimen into the transport medium in the provided biopsy tube
  - Seal cap tightly

Note: Biopsy tube exterior is not sterile
- A circulating nurse should hold the exterior of the tube away from the sterile field
- Surgical team should not directly contact the tube exterior and rim

- Complete each field of the Cartilage Biopsy Transmittal Notice
  - The Patient Information label from the transmittal notice must be completed and affixed to the container with the patient’s full name and date of biopsy
5 Prepare biopsy for shipment

- Place the specimen into the transport medium in the provided biopsy tube
  - Seal cap tightly

**Note: Biopsy tube exterior is not sterile**
- A circulating nurse should hold the exterior of the tube away from the sterile field
- Surgical team should not directly contact the tube exterior and rim

- Complete each field of the Cartilage Biopsy Transmittal Notice
  - The Patient Information label from the transmittal notice must be completed and affixed to the container with the patient’s full name and date of biopsy

- Package biopsy container with completed documentation and follow instructions for shipment
MACI Overview

1. Defect assessment and cartilage biopsy

2. Cells are isolated and expanded (~4 weeks)

3. Cells are seeded on a collagen membrane (2-4 days)

4. Chondrocyte viability and screening assays

MACI Overview

Defect assessment and cartilage biopsy

Cells are isolated and expanded (~4 weeks)

Cells are seeded on a collagen membrane (2-4 days)

Chondrocyte viability and screening assays

Cell-seeded membrane is implanted via an arthroscopy with fibrin sealant

MACI Implantation: Surgical Overview

1. Expose the defect
2. Debride the defect
3. Create the defect template
4. Prepare the MACI implant
5. Secure the MACI implant in the defect
6. Ensure implant stability

Expose the defect

- Use a straight-leg position with a thigh tourniquet
  - Full knee flexion must be possible
  - Thigh support is helpful
- Limited medial or lateral arthrotomy (extensor mechanism is not violated)
- Multiple lesions or larger lesions may require a more extensive approach
- Tips for exposure:
  Z retractor is placed peripherally around the condyle to retract the capsule, and a Hohmann retractor is placed in the notch to lever the patella and gain good exposure
2 Debride the defect

- Use a sharp No. 15 blade to outline the area of the defect
  - Debride the defect down to the subchondral bone and peripherally until vertical walls of healthy, stable cartilage surround the defect site
  - Remove all damaged and fibrous tissue on the defect bed. Remove the calcified cartilage layer
- Remove as little healthy cartilage as possible
- Avoid accidentally penetrating the subchondral bone plate
  - If bleeding occurs, control by local application of adrenaline or sparingly apply fibrin sealant to bleeding points
- Remove any eburnated bone or osteophytes to the subchondral bone level
- Use saline irrigation to keep exposed cartilage surfaces moist through the case
MACI Implantation

Create the defect template

3. Measure debrided defect with ruler
   • Length x width, independent of shape and form of the lesion

3. Create an exact template of the defect using paper (such as from surgical glove packaging) or sterile aluminum foil (from suture packaging)

3. Using a sterile marking pen, create orientation markers on the template as a definitive guide to match the rotations and surface facing into the defect

3. Use a hook tip to gently circumscribe the defect borders
Create the defect template

- Measure debrided defect with ruler
  - Length x width, independent of shape and form of the lesion
- Create an exact template of the defect using paper (such as from surgical glove packaging) or sterile aluminum foil (from suture packaging)
- Using a sterile marking pen, create orientation markers on the template as a definitive guide to match the rotations and surface facing into the defect
- Use a hook tip to gently circumscribe the defect borders
- Shape the template with scissors
  - Confirm shape by placing template at the lesion site
MACI Implantation

4 Prepare the MACI implant

- Remove MACI implant from the transport box directly before use

  **Note:** Treat outside of secondary MACI container as non-sterile

- Using sterile technique, remove MACI implant from primary container

- Place MACI implant on a sterile intermediary dish, with cell-seeded side facing up
  - Position cut-out corner at bottom left
Prepare the MACI implant

• Remove MACI implant from the transport box directly before use

   Note: Treat outside of secondary MACI container as non-sterile

• Using sterile technique, remove MACI implant from primary container

• Place MACI implant on a sterile intermediary dish, with cell-seeded side facing up
  • Position cut-out corner at bottom left

• Place the template under the MACI implant
  • Take care to minimize handling of the MACI implant

• Use sharp dissecting scissors to shape the MACI implant to match the template

• Place custom shaped implant and any remaining membrane into a separate intermediary dishes
  • Use aseptic technique to transfer media from shipping dish to both intermediary dishes
Secure the MACI implant in the defect

• Confirm resized MACI implant fits:
  • Place MACI implant into the defect with cell-seeded side facing subchondral bone
  • Ensure even fit with no overlapping at the border
    • Reshape if necessary
• Remove implant and apply a thin layer of fibrin sealant to the base of the defect
• Place MACI implant in the defect, making sure to maintain appropriate rotational orientation
  • Apply the custom-fashioned implant into the defect on the bone bed
    • Cell side/rough side should face down, adjacent to the bone
Secure the MACI implant in the defect

- Confirm resized MACI implant fits:
  - Place MACI implant into the defect with cell-seeded side facing subchondral bone
  - Ensure even fit with no overlapping at the border
    - Reshape if necessary
- Remove implant and apply a thin layer of fibrin sealant to the base of the empty defect
- Place MACI implant in the defect, making sure to maintain appropriate rotational orientation
  - Apply the custom-fashioned implant to the defect bone bed
    - Cell side/rough side should face down, adjacent to the bone
- Apply gentle pressure while fibrin polymerizes
Ensure implant stability

- Allow ~3 minutes for fibrin sealant to set
- Fully flex and extend the knee several times and then inspect the implant to ensure it has remained in place
- Correct any instability, which may be caused by:
  - Excessive fibrin sealant
  - Oversized implant
- MACI implant may be secured by additional interrupted sutures using 6.0 Vicryl® if conditions warrant (uncontained or at biomechanical risk)
- Usage of drain is optional
  - If used, position strictly into the contralateral knee recesses
- Close wound in layers
1 Expose the defect
MACI Implantation: Surgical Summary

1 Expose the defect

2 Debride the defect
MACI Implantation: Surgical Summary

1. Expose the defect
2. Debride the defect
3. Create the defect template
MACI Implantation: Surgical Summary

1. Expose the defect
2. Debride the defect
3. Create the defect template
4. Prepare the MACI implant
MACI Implantation: Surgical Summary

1. Expose the defect
2. Debride the defect
3. Create the defect template
4. Prepare MACI Implant
5. Secure the MACI implant in the defect
MACI Implantation: Surgical Summary

1. Expose the defect
2. Debride the defect
3. Create the defect template
4. Prepare MACI Implant
5. Secure the MACI implant in the defect
6. Ensure implant stability
Purpose of the Rehabilitation Guidelines

The following is being provided as general guidelines for rehabilitation following autologous chondrocyte implantation. This is intended for use by physical therapists. Individual results may vary as lesion size, location, and patient age are significant factors in determining a rehabilitation program for each patient.

The information provided in this document is intended for educational purposes. It is not a substitute for medical care nor should it be construed as medical advice or product labeling. Consultation with the patient’s treating surgeon or orthopedist is recommended prior to implementing a rehabilitation program. Encourage patient adherence to the prescribed rehabilitation program.
Introduction

MACI usually performed on symptomatic lesions of:

**Tibiofemoral (TF) joint**
- Femoral condyles contact tibial plateau at full knee extension
- Will dictate which rehabilitation exercises are appropriate

**Patellofemoral (PF) joint**
- Weight bearing and active knee flexion increase contact force
- Protection important in early post-implantation

Rehabilitation after MACI is designed to:
- Protect the graft site
- Induce functional repair tissue
- Allow optimal return to function

MACI rehabilitation guidelines were developed by a team of Australian researchers based on extensive research and a desire to ensure good quality outcomes for patients (Ebert J, et al. 2008)

Individualizing Rehabilitation

Patient variation must be considered:

- Age and physical function
- Body weight/BMI
- Defect location
  - PF defects: focus on progression of ROM
  - TF defects: focus on weight-bearing status
- Defect size
  - >6 cm² may require more conservative rehabilitation
- Multiple defects
- Concomitant surgical procedures

Rehabilitation goals need to be tailored to each individual

BMI, body mass index; PF, patellofemoral; ROM, range of motion; TF, tibiofemoral

Rehabilitation Phases

Rehabilitation Phases

<table>
<thead>
<tr>
<th>Duration</th>
<th>PHASES 1-3</th>
<th>PHASE 4</th>
<th>PHASE 5</th>
<th>PHASES 6-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 Weeks</td>
<td></td>
<td>7-12 Weeks</td>
<td>3-6 Months</td>
<td>6-12 Months</td>
</tr>
</tbody>
</table>

Stage of Tissue Repair

| Implantation and Early Protection | Transition and Proliferation | Remodeling | Maturation (26 Weeks to 3 Years) |

<table>
<thead>
<tr>
<th>Cartilage Regeneration</th>
<th>PHASES 1-3</th>
<th>PHASE 4</th>
<th>PHASE 5</th>
<th>PHASES 6-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restore joint homeostasis and protect neo-repair tissue; soft, white tissue with gel-like appearance</td>
<td>Defect fills with primitive repair tissue; jelly-like firmness, integrated into bone</td>
<td>Chondrocytes produce extracellular matrix; graft begins to firm</td>
<td>Further repair and remodeling; repair tissue starts to resemble surrounding tissue</td>
<td></td>
</tr>
</tbody>
</table>

Phases 1-3: Implantation and Protection
### Phases 1-3: Implantation and Protection

<table>
<thead>
<tr>
<th>WEEKS</th>
<th>PHASE</th>
<th>GOALS</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>1</td>
<td>Maintain joint mobility and muscle tone without placing stress on the implant area</td>
<td>Patient must be proficient in home exercise program and functional activities</td>
</tr>
<tr>
<td>2-3</td>
<td>2</td>
<td>Pain-free, full passive knee extension, limited weight bearing</td>
<td>Have pain-free active knee flexion to 125° and pain-free gait using 1 or 2 crutches, depending on weight-bearing status</td>
</tr>
<tr>
<td>4-6</td>
<td>3</td>
<td>More ROM activities, more strengthening exercises, and greater weight bearing</td>
<td>Weight bearing should progress to 60% with a tibiofemoral graft and to full weight bearing with a patellofemoral graft once cleared by the orthopaedic specialist</td>
</tr>
</tbody>
</table>

Rehabilitation Phase 1 (Week 0-1)

Implantation and Protection

GOALS:

Maintain joint mobility and muscle tone without placing stress on implant area.

Patient needs to be proficient in home exercise program and functional activities.
Phase 1: Post-Surgery (Week 0-1)
Rehabilitation Plan (start on post-operative Day 1)

Pain Control
- Provide appropriate analgesics for pain control

Exercises
- Start 0°-30° CPM of knee flexion
  12-24 hours post-surgery for at least 1 hour each day
- For first 3 weeks, wear ROM control brace
  Set at 0°-30° of knee flexion
- Apply cryotherapy
  20 minutes of ice, at least 3 times per day
- Perform active flexion ankle exercises
- Encourage contraction of quadriceps, hamstrings, and gluteal muscles

Reminders
- Ensure proper breathing techniques during exercise
- Offer information on proper ambulation with crutches, bed transfers, and stairs
- Provide written and verbal instruction on performing daily living activities while limiting weight bearing on knee implant

CPM, continuous passive motion

### Post-Operative Timeline: Phase 1 / Week 1

<table>
<thead>
<tr>
<th>TF Joint</th>
<th>PF Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight-Bearing Status</strong></td>
<td><strong>Ambulatory Aids</strong></td>
</tr>
<tr>
<td>≤20% BW</td>
<td><img src="crutches.png" alt="" /></td>
</tr>
<tr>
<td>20%–30% BW</td>
<td><img src="crutches.png" alt="" /></td>
</tr>
</tbody>
</table>

- BW, body weight; PF, patellofemoral; ROM, range of motion; TF, tibiofemoral

Rehabilitation Phase 2 (Weeks 2-3)
Implantation and Protection (initial outpatient visit)

GOALS:
Pain-free, full passive knee extension
Limited weight bearing
Maintaining muscle tone and ensuring proper wound healing and edema control

Include flexibility, strengthening, and hydrotherapy exercises by Week 3

Phase 2: Post-Surgery (Weeks 2-3)

Patient Goals
By post-surgery Week 3

✓ Achieve pain-free knee flexion
  • 90° for TF grafts
  • 60° for PF grafts

✓ Achieve pain-free and full passive knee extension

✓ Using 2 crutches and a knee brace, proficient heel-to-toe gait
  • With 30% body weight for PF grafts
  • With 50% body weight for TF grafts

✓ Reduced and/or well-controlled post-operative pain and edema

✓ Ability to generate an active, isometric quadriceps contraction

✓ Proficiency with home exercise program

Rehabilitation Plan (by post-surgery Week 3)

Along with the weight bearing, ambulatory aids, knee ROM, and knee bracing exercises, patients should include:

**ROM and flexibility exercises**
- Use CPM at end of session for 20-30 minutes
- Passive and active heel slides
- Passive knee extension
- Slight patellar mobilization in all directions

**Strengthening exercises**
- Contraction and co-contraction of quadriceps
- Contractions of hamstrings, adductor, calf, and gluteal muscles
- Straight-leg-raise activities

**Hydrotherapy exercises** (If available to the patient After 3 weeks/incision healed)
- Deep water walking and calf raises
- Straight-leg hip movements
- Passive knee flexion
- Hamstring and calf stretching

### Post-Operative Timeline:
#### Phase 2 / Weeks 2-3

<table>
<thead>
<tr>
<th>Weight-Bearing Status</th>
<th>Ambulatory Aids</th>
<th>Knee Bracing</th>
<th>Knee ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30% BW (Week 3)</td>
<td>2 crutches used at all times</td>
<td>0°-30° (Weeks 1-2) to 0°-30° (Weeks 1-2)</td>
<td>Passive and active ROM from: 0°-30° (Week 2) to 90° (Week 3)</td>
</tr>
<tr>
<td><strong>PF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% BW (Week 3)</td>
<td>2 crutches used at all times</td>
<td>Lock brace at full knee extension</td>
<td>Active ROM from: 0°-30° (Week 2) to 60° (Week 3)</td>
</tr>
</tbody>
</table>

**Clinic and Adjunct Modalities:**
- Perform clearance and lymphatic massage as needed to assist with edema; perform cryotherapy, compression, and elevation to assist with edema

Rehabilitation Phase 3 (Weeks 4-6)
Implantation and Protection

GOALS:
Increased ROM activities
Increased weight bearing
Continued strengthening exercises

Patient Goals
By post-surgery Week 6
✓ Achieve pain-free knee flexion to 125°
✓ Proficiency with home exercise program
✓ Including straight-leg raise
✓ Pain-free gait with 1-2 crutches and knee brace
  • Up to full body weight for PF grafts
  • With 60% body weight for TF grafts

Rehabilitation Plan (by post-surgery Week 6)
Along with the weight bearing, ambulatory aids, knee ROM, and knee bracing exercises, patients should include:

**ROM and flexibility exercises**
- Continue Phase 1 and 2 flexibility/stretching exercises
- Stretch hamstrings and calf musculature
- Careful patellar mobilization in all directions
- Use CPM to maximum comfortable range as required

**Strengthening exercises**
- Continue Phase 1 and 2 strengthening exercises
- Progress straight-leg-raise activities
- Introduce gluteal, calf, hip, and trunk strengthening exercises
- Begin recumbent cycling (Weeks 5-6)

**Hydrotherapy exercises**
- Continue Phase 2 hydrotherapy exercises
- Begin active knee flexion exercises, shallow water walking, shallow water calf raises, deep water squats, and pool cycling
### Post-Operative Timeline: Phase 3 / Weeks 4-6

<table>
<thead>
<tr>
<th>Weight-Bearing Status</th>
<th>Ambulatory Aids</th>
<th>Knee Bracing</th>
<th>Knee ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40%-60% BW (Weeks 4-6)</td>
<td>1-2 crutches</td>
<td>0°-60° (Week 4) to Full flexion (Week 6)</td>
<td>Active ROM from: 0°-110° (Week 4) to 125° (Week 6)</td>
</tr>
<tr>
<td><strong>PF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%-full BW (Week 6)</td>
<td>1-2 crutches (Weeks 4-5); 1 crutch as required beginning (Week 6)</td>
<td>Use brace as required (Week 6) Clinic and adjunct modalities</td>
<td>Active ROM from: 0°-90° (Week 4) to 125° (Week 6)</td>
</tr>
</tbody>
</table>

**Clinic and Adjunct Modalities:**
- Perform clearance and lymphatic massage as required; perform cryotherapy, compression, and elevation as required

---

Transition and Proliferation Phase 4
## Transition and Proliferation Phase 4

<table>
<thead>
<tr>
<th>WEEKS</th>
<th>PHASE</th>
<th>GOALS</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-12</td>
<td>4</td>
<td>Movement without ambulatory devices Increased proficiency with rehabilitation exercises</td>
<td>Voluntary quad activity Full ROM 125° Full passive knee Strength level Hams 20% contralateral Quads 30% contralateral Walk 1-2 minutes Minimal pain and swelling</td>
</tr>
</tbody>
</table>

Rehabilitation Phase 4 (Weeks 7-12)
Transition and Proliferation

GOALS:
Movement without ambulatory devices
Increased proficiency with rehabilitation exercises

Patient Goals
By post-surgery Week 12

✓ Achieve pain-free active knee ROM
  0° to 130°-160°

✓ Ability to walk a pain-free 6-minute walk test
  Without ambulatory aids

✓ Pain-free upright cycle ergometry
  Without the knee brace

✓ Proficiency in home- and gym-based exercises

✓ At the end of Phase 4, patients undergo a 3-month post-surgery assessment

Phase 4: Post-Surgery (Weeks 7-12)

Rehabilitation Plan (by post-surgery Week 12)

Along with the weight bearing, ambulatory aids, knee ROM, and knee-bracing exercises, patients should include:

ROM and flexibility exercises
- Continue Phase 2-3 flexibility/stretching exercises
- Stretch quadriceps musculature (Weeks 9-10)
- Begin passive knee ROM on rowing ergometer (Weeks 9-10)
- Careful patellar mobilization in all directions
- Use CPM to maximum comfortable range as required

Strengthening exercises
- Continue Phase 2-3 strengthening exercises
- Introduce standing hip and weighted knee flexion strengthening exercises
- Begin upright cycling (Weeks 9-12)

Phase 4: Post-Surgery (Weeks 7-12)

Rehabilitation Plan (by post-surgery Week 12)
Along with the weight bearing, ambulatory aids, knee ROM, and knee-bracing exercises, patients should include:

Hydrotherapy exercises
- Continue Phase 2-3 hydrotherapy exercises
- Stretch quadriceps and progress water squats
- Begin weight-supported lunge and “step up and down” activities
- Begin “patter” kick (Week 12)

Proprioception exercises
(beginning after return to full weight bearing)
- Progress from partial to full weight bearing by altering:
  - Postural position
  - Environment
  - Proprioceptive input mechanisms
  - Speed of movement
  - Base of support
    - Magnitude and stability
    - “Weight transfer” and/or “sport-specific drills”

Post-Operative Timeline:
Phase 4 / Weeks 7-12

<table>
<thead>
<tr>
<th>Weight-Bearing Status</th>
<th>Ambulatory Aids</th>
<th>Knee Bracing</th>
<th>Knee ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>80% (Week 7)</strong></td>
<td>1 crutch as needed in outdoor/unfamiliar</td>
<td>Discontinue after 6 weeks if no extensor lag with SLR</td>
<td>Progress to full active ROM: (Weeks 7-8)</td>
</tr>
<tr>
<td><strong>(Weeks 8-10)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Full BW as tolerated</strong></td>
<td>No crutches</td>
<td>NO brace</td>
<td>Progress to full active ROM: (Weeks 7-8)</td>
</tr>
</tbody>
</table>

**Begin proprioception exercises after full BW is achieved**

Remodeling Phase 5
## Remodeling Phase 5

<table>
<thead>
<tr>
<th>WEEKS</th>
<th>PHASE</th>
<th>GOALS</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-26</td>
<td>5</td>
<td>Return to work</td>
<td>Full pain-free ROM</td>
</tr>
<tr>
<td>(3-6 Mo)</td>
<td>Remodeling</td>
<td>Have a normal gait pattern</td>
<td>Strength with 85% of contralateral extremity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Balance and/or stability 75% of contralateral extremity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No pain after 30 minutes of light-impact activity</td>
</tr>
</tbody>
</table>

Rehabilitation Phase 5 (Months 3-6)

Remodeling

GOALS:

Have a normal gait pattern

Patient Goals

By post-surgery Week 12

✓ Achieve normal gait without pain or ambulatory aids
✓ Ability to negotiate stairs and mild gradients
✓ Proficiency in performing weighted leg press
  - 60°-90° knee flexion
  - To maximum of 50% of body weight pressure
✓ Proficiency in performing full weight-bearing proprioception activities

**Phase 5: Post-Surgery (Months 3-6)**

**Rehabilitation Plan** (by post-surgery Month 6)

Along with the weight bearing and knee ROM exercises, patients should also perform:

**ROM and flexibility exercises**
- Continue Phase 3-4 flexibility/stretching exercises

**Strengthening exercises**
- Continue Phase 3-4 strengthening exercises
- Introduce bridging exercises and standing single-leg calf raises
- Introduce modified open kinetic chain (OKC) and closed kinetic chain (CKC) exercises
  - OKC: terminal leg extension
  - CKC: inner-range quadriceps; leg press activities
- Progress upright stationary and outdoor road cycling
- Begin rowing ergometry as tolerated

**Post-Operative Timeline:**
*Phase 5 / (Months 3-6)*

<table>
<thead>
<tr>
<th>Weight-Bearing Status</th>
<th>Ambulatory Aids</th>
<th>Knee Bracing</th>
<th>Knee ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full WB as tolerated</td>
<td>No crutches</td>
<td>NO brace</td>
<td>Full and pain-free active ROM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PF Joint</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full WB as tolerated</td>
<td>No crutches</td>
<td>NO brace</td>
<td>Full and pain-free active ROM</td>
</tr>
</tbody>
</table>

Maturation Phases 6-7
## Maturation Phases 6-7

<table>
<thead>
<tr>
<th>WEEKS</th>
<th>PHASE</th>
<th>GOALS</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-36</td>
<td>6 Maturation</td>
<td>Increase difficulty of exercises</td>
<td>Clearance by physician</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return to low-impact recreational activities</td>
<td>Graft able to withstand the specific demands of activities as evaluated by functional tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Be able to walk more than 5 km</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light jogging</td>
<td></td>
</tr>
<tr>
<td>37-52</td>
<td>7 Return to sports</td>
<td>Resume all normal functionality</td>
<td></td>
</tr>
<tr>
<td>(9-12 Mo)</td>
<td></td>
<td>Return to low-compression recreational activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Running/pivotal activities</td>
<td></td>
</tr>
</tbody>
</table>

Rehabilitation Phase 6 (Months 6-9)

Maturation

GOALS:
- Increase difficulty of exercises
- Return to low-impact recreational activities
- Be able to walk more than 5 km

Patient Goals
By post-surgery Month 9

✔ Achieve hamstring and calf strength within 80%-90% of the contralateral leg

✔ Ability to tolerate walking distances of more than 5-10 km

✔ Ability to negotiate uneven ground

✔ Return to pre-operative low-impact recreational activities

Phase 6: Post-Surgery (Months 6-9)

Rehabilitation Plan (by post-surgery Month 9)

Patients should continue to perform:

ROM and flexibility exercises
- Continue Phase 3-4 flexibility/stretching exercises

Strengthening exercises
- Continue Phase 3-5 strengthening exercises
- Progression and increased difficulty of OKC and CKC exercises
  - CKC: step ups/downs; modified squat activities
- Begin controlled running on a mini-trampoline

Rehabilitation Phase 7
(Months 9-12 and Return to Sports)

Maturation

Goals (Months 9-12):
Resume all normal functionality

Return to low-compression recreational activities

Patient Goals
By post-surgery Month 12

✔ Ability to perform all activities of daily living
✔ Ability to return to a running program
✔ Return to dynamic recreational activities

Individual loading program
- Low-impact sports: 4-6 months
- Moderate-impact sports: 8 months
- High-impact sports: 12-18 months
- Criteria for return based on sports/activity-specific needs

Phase 7: Post-Surgery (Months 9-12 and Return to Sports)

Rehabilitation Plan (by post-surgery Month 12)
Patients should continue to perform:

ROM and flexibility exercises
• Continue Phase 3-4 flexibility/stretching exercises

Strengthening exercises
• Continue Phase 3-6 strengthening exercises
• Progression and increased difficulty of CKC exercises
  Lunge and squat activities on unstable surfaces
• Begin agility drills relevant to the patient’s sport

## Considerations for Concomitant Procedures

<table>
<thead>
<tr>
<th>Concomitant Procedure</th>
<th>Rehabilitation Variations</th>
</tr>
</thead>
</table>
| Meniscal allograft          | • Rehabilitation is altered to allow healing of meniscus allograft  
                              • Weight bearing similar to isolated femoral condyle lesion  
                              • ROM progression is slightly slower  
                              • No active knee flexion is allowed past 90° for the first 6-8 weeks  
                              • Resisted hamstring exercises are avoided for the first 12 weeks |
| High tibial osteotomy       | • Rehabilitation is altered to allow healing of the tibial osteotomy  
                              • Return to weight bearing at approximately 6-8 weeks, depending on radiographic evidence of bone healing  
                              • Slightly quicker return to full ROM to prevent motion loss  
                              • The use of heel wedges, orthotics, and/or unloading knee braces is recommended when weight bearing is progressed |
| Anterior cruciate ligament reconstruction | • Dependent on graft selection (patellar tendon, hamstring, allograft)  
                              • Weight bearing similar to isolated femoral condyle lesion  
                              • Femoral condyle: Quicker progression to full ROM to prevent motion loss  
                              • Trochlea: Conservative approach to full ROM |
| Distal realignment          | • Rehabilitation is altered to minimize strain on tibial tubercle  
                              • Slower progression to full ROM, from 0°-90° for up to the first 4 weeks  
                              • Immediate partial weight bearing in extension is possible  
                              • Active knee extension exercises are avoided for the first 6-8 weeks |

**Summary of Rehab Program**

<table>
<thead>
<tr>
<th>Continuous Passive Motion</th>
<th>Begin 12-24 hours after surgery, continue for 6 hours per day for 6 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Bearing</td>
<td>Gradual progression from touchdown for 2 weeks to full weight at 8 weeks, as tolerated by the patient</td>
</tr>
<tr>
<td>Range of Motion</td>
<td>0°-90° for first week; increase by 10° per week to 135° Stationary bike at 4 weeks</td>
</tr>
<tr>
<td>Strengthening</td>
<td>Quadriceps strength is restored initially followed by CORE lower extremities Elliptical trainer at 2-3 months</td>
</tr>
<tr>
<td>Impact Loading</td>
<td>Low impact 5-6 months; jogging 6-7 months Return to sports at 12-18 months</td>
</tr>
<tr>
<td>Special Considerations</td>
<td>Trochlea implants: no open chain or shear loading for first 3 months Combined procedures (eg, ACL repair): follow ACI rehab first</td>
</tr>
</tbody>
</table>

Data on File. Vericel Corporation.
Patient Case
Chapter 5
Patient Case Template

- Age
- Gender
- Lifestyle/occupation
- Activity level
- Symptoms/duration of symptoms
- Acute/recurrent injury
- Patient’s expectations and goals
- Imaging results
- Location of lesion(s)
- Effusion?
- Range of motion
- Prior treatments
- Comorbidities

Placeholder for imaging
- Surface area of lesion(s)
- Depth in bone
- Any comorbidities addressed
• Provide a brief description of the surgical procedure

Placeholder for surgery photograph
- Physical therapy summary
- Pain level
- Weight bearing
- Range of motion
- Strength
- Impact loading
- Return to activities