

# Rehabilitation Guidelines for MACI Procedure - Knee

There are two types of cartilage in the knee; meniscus and articular cartilage. There are two menisci in the knee; a medial meniscus and a lateral meniscus. Menisci are semilunar wedges that sit between the femur (thigh bone) and tibia (shin bone). The menisci are primarily composed of fibrocartilage, with about 75% of the dry weight being type I collagen. The function of the menisci is to protect the other type of cartilage in the knee – the articular cartilage.

The articular cartilage is a layer of hyaline cartilage that covers the end of bones that articulate with other bones. In the knee you have articular cartilage on the end of the femur (femoral condyles), the top of the tibia (tibial plateau) and the back of the knee cap (patella). The articular cartilage has a frictional coefficient approximately 1/5 of ice on ice – i.e. rubbing articular cartilage on articular cartilage would be five times smoother than rubbing ice on ice. This allows for a very smooth gliding surface. A large portion of articular cartilage is fluid, which provides significant resistance to compressive forces.

During athletic trauma or injury, focal areas of the articular cartilage can be damaged or torn. This is referred to as an articular cartilage lesion. (see figure 1) When this happens you lose the normal smooth gliding articulation and the

ability to resist compressive forces at the joint. These changes can cause pain, swelling, loss of motion, weakness and reduced function or performance.

One option for treating articular cartilage lesions of the knee is a MACI procedure. The MACI procedure places cartilage cells harvested from into a sheath or film made from pig tissue. During the surgery the articular cartilage lesion is shaved of any frayed cartilage edges. Then your own cells are expanded and placed onto a film that is implanted into the area of the cartilage damage and absorbed back into your own tissue. These cartilage cells then regenerate, forming a repair tissue that fills the cartilage defect.

The rehabilitation process is crucial in the success of this. Limiting weight bearing early allows for filling of the defect and regeneration of the cartilage cells. Strengthening exercises in the later phases of rehabilitation provides the capacity to protect the knee joint from increased loading on the new cartilage cells and surface.

Return to non-impact sports and activities of daily living after a MACI procedure can be expected. The ability to return to impact sports (running and jumping) is more limited. Successful outcome and return to activity is dependent on the post-operative rehabilitation



**Figure 1:** Full thickness articular cartilage lesion on the femoral condyle of the knee, exposing the subchondral plate

program, patient's age, body mass, lesion size, duration of symptoms prior to surgery, presence of arthritis and previous surgery. Some patient's may not be candidates for the MACI procedure.

Post-operative rehabilitation is an important factor in achieving a successful outcome from a MACI procedure. The UW Health Sports Medicine rehabilitation guidelines are presented in a criterion based progression. Specific time frames, restrictions and precautions are given to protect healing tissues and the surgical repair/reconstruction. General time frames are also given for reference to the average, but individual patients will progress at different rates depending on their age, associated injuries, pre-injury health status, rehab compliance and injury severity. Injury severity refers to the size and location of the articular cartilage lesion.

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Lesions that are larger or are in predominantly weight bearing locations will progress more slowly than smaller or non-weight bearing lesions. Specific attention must be

given to impairments that caused the initial problem. If the patient is s/p medial compartment lesion and they have a varus alignment, post-operative rehabilitation should

include correcting muscle imbalances or postures that create medial compartment stress.

### PHASE I (surgery to 3 weeks after surgery)

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| <b>Appointments</b>                    | <ul style="list-style-type: none"> <li>• Rehabilitation appointments begin 6-10 days after surgery once per week</li> </ul>   |
| <b>Rehabilitation Goals</b>            | <ul style="list-style-type: none"> <li>• Protection of the post-surgical knee</li> <li>• Restore knee range of motion (ROM) to 0°-90° and patellar mobility</li> <li>• Eliminate swelling</li> <li>• Restore leg control</li> </ul>   |
| <b>Precautions</b>                     | <p><b>Tibiofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Use axillary crutches, partial weight bearing (PWB) (30% BW or less), brace 0-45°</li> </ul> <p><b>Patellofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Use axillary crutches, PWB (50% BW or less), locked in full extension</li> </ul>   |
| <b>Range of Motion (ROM) Exercises</b> | <p>Tibiofemoral grafts = 0-90° ROM desired<br/>Patellofemoral grafts = 0-60° ROM desired</p> <ul style="list-style-type: none"> <li>• Knee extension on a bolster</li> <li>• Prone hangs</li> <li>• Supine wall slides as tolerated without pain</li> <li>• Passive range of motion (PROM) off the end of the table as tolerated without pain</li> <li>• Patellar mobilizations, grade 2</li> <li>• CPM machine</li> <li>• Biking partial arcs – use contra-lateral leg to create ipsilateral passive range of motion (PROM)</li> </ul> |
| <b>Suggested therapeutic exercise</b>  | <ul style="list-style-type: none"> <li>• Quad sets (+/- NMES)</li> <li>• SLRs (+/- NMES)</li> <li>• Four way leg lifts in non-weight bearing (NWB)</li> <li>• Patellar mobilizations</li> <li>• Begin pool at axilla level when incisions are healed</li> </ul>   |
| <b>Cardiovascular Exercise</b>         | <ul style="list-style-type: none"> <li>• Upper body circuit training or upper body ergometer (UBE)</li> </ul>   |
| <b>Progression Criteria</b>            | <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Full knee extension</li> </ul>  |

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### PHASE II (begin after meeting Phase 1 criteria, usually 4-6 weeks after surgery)

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| <b>Appointments</b>                    | <ul style="list-style-type: none"> <li>• Rehabilitation appointments are 1 time per week</li> </ul>   |
| <b>Rehabilitation Goals</b>            | <ul style="list-style-type: none"> <li>• Protection of the post-surgical knee</li> <li>• Restore normal knee ROM to 0-125° and patellar mobility</li> <li>• Eliminate swelling</li> <li>• Restore leg control</li> </ul>  |
| <b>Precautions</b>                     | <p><b>Tibiofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Use axillary crutches, PWB (60% BW or less), unlocked brace</li> </ul> <p><b>Patellofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Use axillary crutches, WBAT, unlocked brace</li> </ul>   |
| <b>Range of Motion (ROM) Exercises</b> | <p>Tibiofemoral grafts = 0-125° ROM desired<br/>                     Patellofemoral graft s= 0-125° ROM desired</p> <ul style="list-style-type: none"> <li>• Knee extension on a bolster</li> <li>• Prone hangs</li> <li>• Supine wall slides as tolerated without pain</li> <li>• PROM off the end of the table as tolerated without pain</li> <li>• CPM machine</li> <li>• Biking partial arcs – use contra-lateral leg to create ipsilateral PROM</li> </ul> |
| <b>Suggested Therapeutic Exercise</b>  | <ul style="list-style-type: none"> <li>• Quad sets (+/- NMES)</li> <li>• SLRs (+/- NMES)</li> <li>• Four way leg lifts in non-weight bearing</li> <li>• Patellar mobilizations</li> <li>• Begin pool at axilla level when incisions are healed</li> </ul>   |
| <b>Cardiovascular Exercise</b>         | <ul style="list-style-type: none"> <li>• Upper body circuit training or UBE</li> </ul>  |
| <b>Progression Criteria</b>            | <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Full knee extension</li> </ul>  |

### PHASE III (begin after meeting Phase II criteria, usually 7-12 weeks after surgery)

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| <b>Appointments</b>         | <ul style="list-style-type: none"> <li>• Rehabilitation appointments are 1 time per week</li> </ul>   |
| <b>Rehabilitation Goals</b> | <ul style="list-style-type: none"> <li>• Protection of the post-surgical knee</li> <li>• Restore normal knee ROM to 0-125° and patellar mobility</li> <li>• Recovery of muscle performance</li> <li>• Restore weight bearing leg control</li> </ul> |

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| <b>Precautions</b>                     | <p><b>Tibiofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Axillary crutches as needed, WBAT, unlocked brace</li> </ul> <p><b>Patellofemoral grafts:</b></p> <ul style="list-style-type: none"> <li>• Axillary crutches as needed, WBAT, no brace</li> </ul>   |
| <b>Range of Motion (ROM) Exercises</b> | <p>0-125° ROM desired, continue exercises as needed to achieve</p> <ul style="list-style-type: none"> <li>• Knee extension on a bolster</li> <li>• Prone hangs</li> <li>• Knee to chest pulls for flexion</li> <li>• CPM machine</li> <li>• Biking with little to no resistance</li> <li>• Begin gentle quadriceps stretching</li> </ul>  |
| <b>Suggested Therapeutic Exercises</b> | <ul style="list-style-type: none"> <li>• Non-impact balance and proprioceptive drills. Start with double leg support and gradually progress to single leg support when safe and symptom free</li> <li>• Gait drills</li> <li>• Hip and core strengthening</li> <li>• Stretching for patient specific muscle imbalances</li> <li>• Quad strengthening – closed chain exercises short of 50° knee flex</li> <li>• Continue pool program – alternating days with land program</li> </ul> |
| <b>Cardiovascular Exercise</b>         | <ul style="list-style-type: none"> <li>• Upper body circuit training or UBE</li> </ul>  |
| <b>Progression Criteria</b>            | <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Full knee extension</li> </ul>  |

### PHASE IV (begin after meeting Phase III criteria, usually 3-6 months after surgery)

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| <b>Appointments</b>                    | <ul style="list-style-type: none"> <li>• Meet with physicians at 12 weeks post-op</li> <li>• Rehabilitation as needed</li> </ul>  |
| <b>Rehabilitation Goals</b>            | <ul style="list-style-type: none"> <li>• Good control</li> <li>• No pain with sport/work specific movements, including impact</li> </ul>  |
| <b>Precautions</b>                     | <ul style="list-style-type: none"> <li>• Post-activity soreness should resolve within 24 hours</li> <li>• Avoid post-activity swelling</li> <li>• Avoid knee pain with impact</li> </ul>  |
| <b>Suggested Therapeutic Exercises</b> | <ul style="list-style-type: none"> <li>• Non-impact balance and proprioceptive drills. Start with double leg support and gradually progress to single leg support when safe and symptom free</li> <li>• Progression to higher velocity non-impact gait and movement drills; deep water running, elliptical, biking with resistance, rowing ergometer</li> <li>• Progression of closed chain strengthening without impact through a greater ROM; squats, lunge walks, multi-directional lunge patterns, step up and step-down patterns, leg press</li> <li>• Hip and core strengthening</li> </ul> |

## Rehabilitation Guidelines for MACI Procedure - Knee

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|--------------------------------------|---|
| <b>Cardiovascular Exercise</b>       | <ul style="list-style-type: none"> <li>• Replicate sport or work specific energy demands</li> </ul>   |
| <b>Progression Criteria</b>          | <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Full knee extension</li> </ul>  |
| <b>Return to Sport/Work Criteria</b> | Return to non-impact sports and work activities allowed if: <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Quadricep and hamstring peak torque and total work at 85% limb symmetry index</li> <li>• Good movement control and balance</li> </ul> |

### PHASE V (begin after meeting Phase IV criteria, usually 9-16 months after surgery)

NOTE: This phase is dependent upon the patient. For some patients it may be advisable to minimize impact sports for life. In these cases, this phase is not applicable.

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| <b>Appointments</b>                    | <ul style="list-style-type: none"> <li>• Meet with the Physician at 36 weeks post-op</li> <li>• Rehabilitation as needed</li> </ul>  |
| <b>Rehabilitation Goals</b>            | <ul style="list-style-type: none"> <li>• Good control</li> <li>• No pain with sport/work specific movements, including impact.</li> </ul>  |
| <b>Precautions</b>                     | <ul style="list-style-type: none"> <li>• Post-activity soreness should resolve within 24 hours</li> <li>• Avoid post-activity swelling</li> <li>• Avoid knee pain with impact</li> </ul>   |
| <b>Suggested Therapeutic Exercises</b> | <ul style="list-style-type: none"> <li>• Impact control exercises beginning 2 feet to 2 feet, progressing from 1 foot to other and then 1 foot to same foot.</li> <li>• Movement control exercise beginning with low velocity, single plane activities and progressing to higher velocity, multi-plane activities</li> <li>• Sport/work specific balance and proprioceptive drills</li> <li>• Hip and core strengthening</li> <li>• Stretching for patient specific muscle imbalances</li> </ul> |
| <b>Cardiovascular Exercise</b>         | <ul style="list-style-type: none"> <li>• Replicate sport/work specific energy demands</li> </ul>   |
| <b>Return to Sport/Work Criteria</b>   | Return to non-impact sports and work activities allowed if: <ul style="list-style-type: none"> <li>• No swelling</li> <li>• Quadricep and hamstring peak torque and total work at 90% limb symmetry index</li> <li>• Acceptable impact control (minimal variability and within 20% symmetry) with force plate jump assessment</li> <li>• Good control and postural position upon single leg landing.</li> </ul>  |

These rehabilitation guidelines were developed collaboratively between UW Health Sports Rehabilitation and the UW Health Sports Medicine physician group.

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### REFERENCES

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