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Rehabilitation following autologous chondrocyte implantation

DISCLAIMER: The intent of this protocol is to provide therapists with guidelines for rehabilitation of patients that have undergone surgery with Dr. Avallone. It is from the protocol presented in **JOSPT 36 (10) 774-794** and is specific to his operative technique. **PTs are encouraged to read this article.** It is not intended to serve as a substitute for sound clinical decision making. Therapists should consult with Dr. Avallone if they require assistance in the progression of post-operative patients.

Phase 1. Proliferation phase (weeks 0-6)

Goals

- Protect healing tissue from load and shear forces
- Decrease pain and effusion
- Restoration of full passive knee extension
- Gradually improve knee flexion
- Regain quadriceps control

Brace

- Locked at 0° during weight-bearing (WB) activities
- Sleep in locked brace for 2-4 wk

Weightbearing (WB) **with brace locked in full extension**

- WB status varies based on lesion location and size
 - Femoral condyle lesions
 - Weeks 1-2: non-WB OR toe-touch WB immediately per MD if lesion <2.0 cm²
 - Weeks 2-3: begin toe touch weight bearing (approximately 9.1-13.6 kg)
 - Weeks 4-5: progress to partial WB (approximately ¼ body weight)
 - Patellofemoral lesions
 - Immediate: toe-touch WB ~25% body weight
 - Week 2: progress to 50% WB at week 2
 - Weeks 3-4: progress to 75% WB

Range of motion (ROM)

- CPM
 - Initiate CPM day 1 for total of 8-12 hours/day
 - Femoral condyle lesions or patellofemoral lesions <6.0 cm²: 0°-60°
 - Patellofemoral lesions >6.0 cm²: 0°-40°
 - Progress CPM ROM as tolerated 5°-10° day
 - May continue CPM for total of 6-8 hours/day for up to 6 weeks
 - **D/C CPM when ROM GOALS??**
- Initiate motion exercises day 1
- Patellar mobilization (4-6 times per day)
- Motion exercises throughout the day
- Passive knee flexion ROM at least 2-3 times daily
- Passive knee ROM as tolerated
- FLEXION ROM GOALS for femoral condyle lesions: knee flexion 90° by weeks 1-2, 105° by week 3, 115° by week 4, and 120°-125° by week 6
- FLEXION ROM GOALS for patellofemoral lesions: knee flexion 90° by weeks 2-3, 105° by 3-4 weeks, and 120° by week 6
- EXTENSION ROM GOAL: immediate full passive knee extension
- Stretch hamstrings and calf

Strengthening program

- CONTRAINDICATIONS: No active knee extension exercises for patellofemoral lesions
- Ankle pump using elastic tubing
- Quadriceps setting
- Multi-angle isometrics (cocontractions Q/H)
- Active knee extension 90°-40° for femoral condyle lesions only (no resistance)

- Straight leg raises (4 directions)
- Stationary bicycle when ROM allows, low resistance
- Electrical muscle stimulation and/or biofeedback during quadriceps exercises
- Isometric leg press at week 4 (multi-angle)
- May begin use of pool for gait training and exercises week 4
- Initiate weight-shifting exercises with knee in extension by weeks 2-3 for patellofemoral lesions

Functional activities

- Gradual return to daily activities
- If symptoms occur, reduce activities to reduce pain and inflammation
- Extended standing should be avoided

Swelling control

- Ice, elevation, compression, and modalities as needed to decrease swelling

Criteria to progress to Phase 2

- Full passive knee extension
- Knee flexion to 120°
- Minimal pain and swelling
- Voluntary quadriceps activity

Phase 2. Transition phase (weeks 6-12)

Goals

- Gradually increase ROM
- Gradually improve quadriceps strength/endurance
- Gradual increase in functional activities

Brace

- Discontinue brace at week 6
- Consider unloading knee brace for femoral condyle lesions

Weightbearing

- Progress WB as tolerated
 - For femoral condyle lesions: ½ body weight with crutches at 6 wk, progress to full WB at 8-9 wk, discontinue crutches
 - For patellofemoral lesions: progress to full WB at 6-8 wk, discontinue crutches

ROM

- Gradual increase in ROM
- Maintain full passive knee extension
- Progress knee flexion to 125°-135° by week 8
- Continue patellar mobilization and soft tissue mobilization, as needed
- Continue stretching program

Strengthening exercises

- Progress WB exercises
- Initiate weight shifts week 6 for femoral condyle lesions
- Leg press weeks 7-8
- Mini-squats 0°-45° by week 8
- Toe-calf raises at week 6 for patellofemoral lesions, at week 8 for femoral condyle lesions
- Progress balance and proprioception drills
- Initiate front lunges, wall squats, front and lateral step-ups by weeks 8-10
- For femoral condyle lesions, progress non-WB knee extension, 0.45 kg/wk
- For patellofemoral lesion, may begin non-WB knee extension without resistance in a ROM that does not allow for articulation of the lesion
- Stationary bicycle, low resistance (gradually increase time)
- Treadmill walking program by weeks 10-12
- Continue use of electrical muscle stimulation and or biofeedback as needed
- Continue use of pool for gait training and exercise

Functional activities

- As pain and swelling diminish, the patient may gradually increase functional activities
- Gradually increase standing and walking

Criteria to progress to Phase 3

- Full ROM
- Acceptable strength level
- Hamstrings within 20% of contralateral extremity
- Quadriceps within 30% of contralateral extremity

- Balance testing within 30% of contralateral extremity
- Able to walk 1.6-3.2 km or bike for 30 min

Phase 3. Remodeling phase (weeks 12-26)

Goals

- Improve muscular strength and endurance
- Increase functional activities

ROM

- Patient should exhibit 125°-135° flexion

Exercise program

- Leg press (0°-90°)
- Bilateral squats (0°-60°)
- Unilateral step-ups progressing from 5.1 to 20.3 cm
- Forward lunges
- Walking program
- Progress non-WB extension (0°-90°), for patellofemoral lesions perform from 90°-40° or avoid angle where lesion articulates, progress 0.45 kg every 2 wk beginning week 20 if no pain or crepitation, must monitor symptoms
- Continue progressing balance and proprioception
- Bicycle
- Stairmaster
- Swimming
- Nordic-Trak/elliptical

Functional activities

- Increase walking (distance, cadence, incline, etc)

Maintenance program

- Initiate at weeks 16-20
- Bicycle: low resistance, increase time
- Progressive walking program
- Pool exercises for entire lower extremity
- Straight leg raises
- Leg press
- Wall squats
- Hip abduction/adduction
- Front lunges
- Step-ups
- Stretch quadriceps, hamstrings, calf

Criteria to progress to Phase 4

- Full non-painful ROM
- Strength within 80%-90% of contralateral extremity
- Balance and/or stability within 75%-80% of contralateral extremity
- No pain, inflammation, or swelling

Phase 4. Maturation phase (weeks 26-52)

Goals

- Gradual return to full unrestricted functional activities

Exercises

- Continue maintenance program progression 3-4 times per wk
- Progress resistance as tolerated
- Emphasis on entire lower extremity strength and flexibility
- Progress agility and balance drills
- Impact loading program should be individualized to the patient's needs
- Progress sport programs depending on patient variables

Functional activities

- Patient may return to various sport activities as progression in rehabilitation and cartilage healing allows. Generally, low-impact sports, such as swimming, skating, rollerblading, and cycling, are permitted at about 6 mo. Higher-impact sports, such as jogging, running, and aerobics, may be performed at 8-9 months for small lesions or 9-12 mo for larger lesions. High-impact sports, such as tennis, basketball, football, and baseball, are allowed at 12-18 months