

Rehabilitation after Cartilage Surgery

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The goal of cartilage rehabilitation after surgery is to optimally support the cartilage repair process. Rehabilitation guidelines are designed to provide a general framework for exercise progression that will help to restore joint function and stability in a safe manner.

Each patient will have a unique response to the surgical procedure and will progress through rehabilitation at a different pace. Significant factors that should be considered when determining a patient's individual post-operative treatment scheme include the lesion size, location of the injury, the patient's age and activity level pre-operatively. It is important to ensure the patient reaches the set rehabilitation goals before allowing increased load or weight bearing on the repaired cartilage.

Careful monitoring and continuous reduction of joint pain and swelling post-operatively is crucial to restore normal muscle activity. Activity levels need to be adjusted accordingly and steps taken to relieve these symptoms. Treatment options for pain and/or swelling may include analgesics, cryotherapy, high-voltage stimulation, ultrasound, and joint compression.

Underlying Processes Important to Rehabilitation

Cartilage has few cells and large quantities of extracellular matrix embedded in collagen but no nerves or blood vessels dispersed in its matrix. It forms a strong, firm but pliable ma-

terial that resists tension, compression, and shear. The chondroitin sulfate in the matrix is largely responsible for cartilage's resilience, or ability to resume its original shape after being deformed.

Cartilage is ideally suited for its primary role to reduce friction at moveable joint surfaces; as the body's principal shock-absorber during walking, running, or jumping.

However, when cartilage is damaged, has degenerated, or a joint is arthritic, the cartilage may no longer be able to absorb the shock or sufficiently protect the subchondral bone. As a result, the loads on the bone increase and the subchondral bone reacts. Thickening of the subchondral bone plate can occur and pain due to bone stress is pre-programmed. Subchondral bone is a significant factor in the healing process of cartilage, also because new blood vessels grow from the subchondral bone into the injured region of the cartilage. This results in increased numbers of repair cells moving into the injured region to promote healing [1, 2].

Post-operative Treatment after Cartilage Surgery

The loads applied to the injured joint should be increased gradually. A slow progression of weight-bearing and range of motion exercises helps reduce complications, including restrictions in motion and formation of scar tissue. This approach also encourages steady improvement and avoids ex-

cessive stress on the healing cartilage. An overaggressive approach early in rehabilitation may result in increased pain, inflammation, or effusion, as well as cartilage damage.

The postoperative therapy can be divided into three stages with the concept of gradual progression applied to strengthening exercises, proprioception training, neuromuscular control drills, and functional drills.

Stage 1: Movement and Mobilisation

The focus of post-operative treatment after cartilage surgery should be to restore joint extension, mobility, and soft tissue flexibility. This will enhance the patient's ability to fully extend the joint and help to return the joint to normal kinematics.

Soft tissue flexibility and pliability are both key. Massage and scar management can be performed to prevent adhesion development around the joint. Flexibility exercises are essential so that the repaired joint achieves full extension immediately following surgery. This may be facilitated through the use of passive extension range of motion and stretching exercises. Compression mobilization stimulates correct adaptation and results in functional restoration of cartilage [3].

Stage 2: Correct Loading vs. Unloading

Cartilage is maintained only where there are actual compressive loads. Under intermittent pressure and shear loading, the cartilage functionally adapts to the various mechanical joint conditions.

Appropriate training supports cartilage hypertrophy and increased load capacity [4]. Physiological loading and unloading promotes the synthesis of joint cartilage cells and thereby regulates the water balance in cartilage tissue [5]. Cartilage can only form an ideal structure for absorbing compression forces if it is filled with water and the extracellular matrix is embedded in collagen. Regular changes in loading and unloading ensure that this optimal constellation remains permanent.

Reduced load capacity of cartilage increases the deformation under load, reduces sliding properties, increases rolling properties, and reduces impact absorption [6].

Stage 3: Movement Combined with Loading

In rehabilitation, cartilage should be exposed to controlled amounts of compressive load during active and passive motions. Loading and movement enable connective tissue cells to adjust and align functionally [7]. Continuous extension and flexion of the knee under light pressure and intermittent compression promote the flow of synovial fluid and nutrients, to support the correct healing/function of the cartilage [8].

Immobilisation can lead to atrophy of muscles, tendon attachments, and the bone surrounding the joint. This also can

result in reduced strength in the intact periarticular tissue and the formation of a non-functional scar in the injured connective tissue [7].

Postoperative Treatment Exercises

A variety of cartilage repair procedures have been developed (especially for athletes) to address focal, full-thickness cartilaginous defects in the knee joint, including microfracture (MFX), osteochondral autografts, osteochondral allografts, autologous chondrocyte implantation, and most recently, autologous matrix induced chondrogenesis (AMIC).

AMIC is an innovative, biological cartilage repair method based on MFX, the body's own healing potential and the regenerative capacity of mesenchymal stem cells. It can be applied to full thickness cartilage defects that extend down to the subchondral bone and are bigger than 1–2 cm². Since its introduction, AMIC proved to be a valid, and simple alternative to other techniques allowing most of the patients to go back to their level of activity before surgery [9–11].

The key postoperative treatment steps after an AMIC procedure are equivalent to those of other cartilage repair techniques. They focus on pain reduction, mobilisation and strength development.

The rehabilitation process should be closely accompanied by the surgeon and physiotherapist and should be adapted to the clinical situation and to the patient's requirements. Table 1. shows our recommendation for postoperative treatment after AMIC.

Rehabilitation exercises can be altered based on the biomechanics of the joint to avoid excessive compressive or shearing forces. Immediate motion as soon as one day after surgery can help avoid range of motion complications and minimize poor functional outcomes. As the cartilage heals and the patient's symptoms subside, the range of motion in the joint should progress to allow greater muscle strengthening.

In patients with a high BMI, therapy should commence with intermittent manual compressions of the joint and a stepwise increase of the load. The load capacity can be determined by implementing a compression test. If this test triggers pain, the force is reduced by half and is used as a therapeutic stimulus. The patient should only be allowed to apply everyday loads once the compression test does not trigger pain.

Electrical muscle stimulation and biofeedback are often incorporated in therapeutic exercises to facilitate the active contraction of muscles. This may facilitate the return of muscle activation and become a valuable addition to therapeutic exercises.

Femoral and tibial defects

	Week 1	Weeks 2–6	after 6 weeks
Load bearing	Light foot contact 3-point-walking with crutches	Light foot contact 3-point-walking with crutches	Progressive increase in load bearing to 100%
Mobilisation	Orthesis in extension	Motorized CPM with restriction Week 2–3: 0/0/60° Week 4–6: 0/0/90°	Free movement (restricted by pain)
Physiotherapy	Manual lymphatic drainage Manual therapy – joint mobilisation	Hydrotherapy Manual therapy – rotational and translational	After 8 weeks – aqua-jogging After 6 months – cycling After 6–12 months – jogging

Patellar and trochlear defects

Load bearing	Light foot contact 3-point-walking with crutches	Progressive increase in load bearing to 100%	
Mobilisation	Orthesis in extension	Motorized CPM with restriction Week 2: 0/0/30° Week 3–4: 0/0/60° Week 5–6: 0/0/90°	Free movement (restricted by pain)

Table 1: Post-operative physiotherapy guidelines after AMIC as implemented in our centre

Rehabilitation after cartilage surgery requires an in-depth understanding of joint mechanics, as well as knowledge of the biologic and biomechanical properties of healing articular cartilage.

For athletes, a sports-specific approach is required on the part of the trainer or physical therapist so that the athlete may be able to return to competition.

Influence of Nutrition and Lifestyle

Restoration and regeneration of cartilage tissue is closely coupled to nutrition, even though few clinical studies support the influence of nutrition on cartilage regeneration. The importance of nutrition can be best explained through connective tissue physiology. For optimal wound healing, the cell needs to receive sufficient vitamins, trace elements, minerals, oxygen, and enzymes via the vascular system. Therefore, it is extremely important that there is good circulation throughout tissues and that diffusion takes place through the interstitial fluid without obstacles [12].

Acidification of the extracellular pH has been shown to modify protein & proteoglycan synthesis in intervertebral disc implants and to inhibit matrix synthesis in human chondrocytes [13–15]. The acid-base equilibrium can be considered one of the most important factors in homeostatic equilibrium. Chondro-

cytes require a pH value of 6.9–7.2 for their synthesis activity [16, 17]. An urine pH of 6.2–7.0 is considered normal. A common reason for excessive acidity of the tissue is high consumption of animal protein, sugar, coffee, and black tea, as well as stress. Consumption of a large amount of polyunsaturated fatty acids results in cell storage of arachidonic acid, which is an inflammation mediator. In excess this promotes the formation of another inflammation mediator, prostaglandin E₂. This increases the possibility of inflammation in a structure that already is weakened and under stress.

Patients should be advised to reduce the intake of proteins and dietary fats common in the following food groups:

- > Meat and meat products (sausage, bacon, pâtés, terrines, etc.)
- > animal fats (lard, butter, cream)
- > whole-milk products

Antioxidants can reduce this inflammatory process. These include: vitamins C and E, and beta-carotene; the minerals zinc and selenium; and the polyunsaturated omega-3 fatty acids. Additionally, patients should be encouraged to drink liquids with electrolytes and minerals (matrix stabilization) for more than 21 days after surgery.

Active and passive smoking also changes the pH value of the tissue to an acidic environment, impairs tissue blood perfu-

sion, and reduces oxygen transport to the cells. Studies have confirmed that smoking has a negative influence on the physiological structuring processes in connective tissue. Smoking could therefore negatively influence the outcome after cartilage repair surgery [18–21].

Conclusion

Restoration of joint function, strengths and stability should have top priority after cartilage surgery. Intermittent compressive forces (active and passive) that correspond to activities of daily living provide the most important stimulus for

cartilage cells, increase and improve load capacity, neutralize or prevent pathological changes in the bone, guarantee nourishment of the cartilage, and are also effective in relieving pain [5]. The load on the repaired cartilage should be increased slowly and gradually, just as in an athlete's training regimen. The success of cartilage rehabilitation depends on the correct dosing and technique, as well as the ability of the patient to take responsibility for his or her body through a healthy lifestyle to provide the optimal conditions for the healing tissue. Postoperative treatment after the AMIC procedure usually results in a full return to non-contact sports within 12 months.

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