

## Appendix 2: KNGF Evidence Statement for anterior cruciate ligament reconstruction rehabilitation

### Inclusion and exclusion criteria for rehabilitation according to the Evidence Statement

Inclusion of patients that:

- had an anterior cruciate ligament reconstruction (ACLR) with an autologous bone-patellar tendon-bone (BPTB) or hamstring (HS) graft;
- are 16 years old or above;
- are athletes or perform physically demanding work;
- have other ligamentous injury grade A or B according to the IKDC classification;
- had a partial meniscectomy previous to or simultaneously with ACLR;
- have cartilage damage grade I or II according to the ICRS classification.

Exclusion of patients that:

- are younger than 16 years old;
- had ACLR with an allograft or synthetic graft;
- had ACL revision surgery;
- have other ligamentous injury grade C or D according to the IKDC classification;
- had meniscal repair simultaneously with ACLR;
- have cartilage damage grade III or IV according to the ICRS classification.

#### *IKDC classification of ligamentous injury*

Grade	ACL, PCL, MCL or LCL	PMC or PLC
A	0-2 mm	<5°
B	3-5 mm	6-10°
C	6-10 mm	11-19°
D	>10 mm	>20°

ACL=anterior cruciate ligament, PCL=posterior cruciate ligament, MCL=medial/tibial collateral ligament, LCL=lateral/fibular collateral ligament, PMC=posteromedial corner, PLC=posterolateral corner

#### *ICRS classification of cartilage damage*

Grade	Classification	Description
0	normal	-
1	nearly normal	Superficial lesions. Soft indentation and/or superficial fissures and cracks.

2	abnormal	Lesions extending down to <50% of cartilage depth.
3	severely abnormal	Cartilage defects extending down to >50% of cartilage depth as well as down to calcified layer and down to but not through the subchondral bone. Blisters are included in this grade.
4	severely abnormal	Osteochondral defects. Lesions extending down through the subchondral bone.

## **Preoperative rehabilitation**

An ACLR should only be done on the condition that:

- the patient has a functional instability with complaints of giving way. In an acute situation, it is difficult to say if there is a functional instability. Therefore, we recommend to avoid ACLR in the acute situation, in order to minimize the chance of operating asymptomatic patients.<sup>139,140</sup>
- the knee has a minimal synovial reaction, the knee has a full extension (0 degrees), there is good patellofemoral mobility (left=right), the patient can actively control the quadriceps and there is a correct gait pattern in order to prevent arthrofibrosis.<sup>47,49,141-144</sup>
- there is a quadriceps strength deficit compared with the healthy leg of maximum 20%. A strength deficit of 20% or more predicts a significant strength deficit until two years after ACLR.<sup>42,121</sup>

We advise the subsequent preoperative treatment:

- The physical therapist should give information about walking with crutches, about the first postoperative exercises and about the complete rehabilitation process. This increases self-efficacy and the subjective and objective outcome at the end of the rehabilitation.<sup>117,145-147</sup>
- When the knee has a limited patellofemoral or tibiofemoral mobility, use mobilization techniques to reach the goals mentioned above.<sup>143,144</sup>
- When there is a quadriceps strength deficit of more than 20%, use closed and open kinetic chain exercise to improve strength.<sup>42,121</sup>

Preoperative measurements of functional performance:

- Stroke test<sup>148</sup>
- Passive range of motion, both patellofemoral and tibiofemoral<sup>143</sup>
- Visual Analogue Scale (VAS), IKDC Subjective knee evaluation form and/or KOOS<sup>140</sup>
- A psychological questionnaire (TSK-11, ACL-RSI, K-SES)
- Strength measurement of the quadriceps and hamstrings.<sup>42,121</sup>

## Postoperative rehabilitation

### Phase 1

Goal: minimal synovitis/effusion, extension 0°, voluntary quadriceps control, active dynamic gait pattern.<sup>140,144</sup>

#### 1. *Level of body functions and structures*

##### a. *Mobility*

- Passive mobilization of the patella (both medial-lateral and inferior-superior translations) when there is a mobility deficit.<sup>149</sup>

Aim at a good patella mobility (left=right) in four to six weeks.

- Active and/or passive knee extension exercises, when there is an extension deficit. If the extension deficit is more than 10°, use heel props.<sup>141,149</sup>

Aim at an extension of 0° in two to four weeks.<sup>141,143,144,149</sup>

- Heel-slides to improve knee flexion.<sup>141</sup>

Aim at 120-130° of flexion in four to six weeks.<sup>141,143,144,149</sup>

N.B. In case of increasing knee temperature, effusion or pain as a reaction to mobilizations, evaluate treatment and re-adjust it by enhancing rest periods, using cryotherapy and/or NSAID's (after consultation of a doctor).<sup>142</sup> Cryotherapy only influences pain, not effusion.<sup>103-107</sup>

##### b. *Strength training*

- Reactivation of the quadriceps: active knee extensions when seated with the legs straightened.<sup>83,90,141</sup> Use manual facilitation techniques or electrostimulation when voluntary contraction of the quadriceps is not possible.<sup>63,93,94,98-101</sup>
- Progress from isometric quadriceps exercise (active straight leg raises, ASLR), to concentric and eccentric exercises provided that the knee does not react with increasing temperature, effusion and/or pain.<sup>71,80-82</sup>
- Closed kinetic chain quadriceps training (ROM 0-60°), for instance with the leg press, squat or step-up.<sup>51,66,87,141,144</sup>

- BPTB-graft: open kinetic chain quadriceps exercises (for instance leg extension) can be performed with resistance from week 4 in ROM 90-45°.<sup>65,66,150</sup>

HS-graft: open kinetic chain quadriceps exercises can be performed without resistance from week 4 in ROM 90-45°.<sup>65,66</sup>

For both BPTB-graft and HS-graft, increase ROM with 10° every week from week 5: week 5 ROM 90-30°, week 6 ROM 90-20°, week 7 ROM 90-10° to full-ROM in week 8.<sup>51,60,141,150</sup>

- Concentric and eccentric strength training of the gluteal muscles, hamstrings and calf muscles.<sup>87</sup>

## 2. *Level of activities and participation*

### a. *Neuromuscular training*

- Neuromuscular training on two legs, for instance on a wobble-board (only forward-backward movements). Gradually increase difficulty by:
  - o adding perturbation, without the patient being able to see what the physical therapist is doing,
  - o training on one leg,
  - o training on an increasingly difficult board,
  - o training with eyes closed,
  - o adding tasks: for example catch and throw a ball or answer a difficult arithmetical problem.<sup>87</sup>
- Encourage a correct quality of performance (e.g. trunk lateroflexion, hip- and knee flexion, dynamic knee valgus and knee-over-toe) during strength training and walking.<sup>51,87,151</sup> Use implicit learning techniques instead of explicit learning techniques.<sup>130,131</sup>

### b. *Walking and bicycling*

- Load the operated leg, if necessary with crutches.<sup>91,141,152</sup> Keep using crutches as long as there is a deviation in the gait pattern. Practice gait in different speeds and on various surfaces.<sup>141</sup>
- Start cycling on a hometrainer when knee flexion reaches 100°.<sup>87,141</sup> Use cycling as a warm-up and mobilization exercise.

### *Criteria to start phase 2:*

- Closed wound
- No knee pain with phase 1 exercises (VAS)<sup>149</sup>
- Minimal synovitis or effusion<sup>149</sup>
- Normal mobility (left=right) of the patellofemoral joint<sup>149</sup>
- Knee extension of at least 0° and a 120-130° flexion<sup>51,140,144,149</sup>
- Voluntary control of the quadriceps<sup>51,141,144</sup>
- Active dynamic gait pattern without crutches
- Correct qualitative performance of phase 1 exercises.

*Abnormal progress if:*

- the wound doesn't close or if there is an infection: refer the patient to the surgeon.
- there is still a considerable amount of mobility loss in the patella after 6 to 8 weeks. Consult the surgeon because of the risk on infrapatellar contracture syndrome.<sup>153-155</sup>
- the (loaded) extension is less than 0° after 6 to 8 weeks or decreases. Consult the surgeon because of the risk on arthrofibrosis or cyclops.<sup>143,156</sup>
- there is still no voluntary quadriceps control after 6 to 8 weeks.
- there is still no dynamic gait pattern.

Phase 2

Goal: performing sport specific tasks and physically demanding work without restrictions.<sup>140</sup>

*1. Level of body functions and structures*

*a. Mobility*

- Maintain full patellofemoral and tibiofemoral range of motion.<sup>51</sup>

*b. Strength training*

- Increase closed kinetic chain quadriceps exercises in range of motion, to full ROM in week 8 and add one-legged exercises (for instance lunges or single-leg squats).<sup>51</sup>
- Increase open kinetic chain quadriceps exercises in range of motion, to full ROM in week 8.<sup>51,66,141</sup>

Note that patients with HS-grafts are allowed to perform open kinetic chain exercises with resistance only from week 12.<sup>60,61,63,66</sup>

- Intensify strength training of the gluteal muscles, hamstrings and calf muscles.
- Decrease repetitions and increase resistance for all strength exercises.<sup>51,141</sup>

*2. Level of activities and participation*

*a. Neuromuscular training*

- Increase difficulty of neuromuscular and perturbation training:
  - o by altering from static to dynamic training,
  - o by altering from forward-backward movements to sideward movements,
  - o by changing predictability, speed, direction and amplitude of the disturbance, for example on a moving platform,
  - o with two-legged jumps, including rotations.<sup>87</sup>
- Keep paying attention to a correct quality of performance during strength training, walking and jogging.

*b. Walking and bicycling*

- Start bicycling outdoors at the start of phase 2.<sup>51</sup>
- Add cyclic training to the program, for example cross-trainer or rowing machine.
- Start jogging in week 10 to 12, but only if it is performed symmetrically and the knee does not react with increasing temperature, effusion or pain.<sup>141,152</sup>
- Aggravate cardiovascular training (mainly aerobic).

*c. Sport specific training*

- Start agility training under supervision of a physical therapist.<sup>87</sup>
- Pay attention to a correct quality of performance.

*Criteria to start phase 3:*

- Correct qualitative performance of phase 2 exercises
- Limb Symmetry Index (LSI) >80% for quadriceps and hamstring strength<sup>51</sup>
- LSI >80% for a hop test battery<sup>51</sup>, with preference towards the hop test battery of Gustavsson<sup>157</sup>
- Complete the IKDC Subjective knee evaluation form and/or KOOS.
- Complete a psychological questionnaire (TSK-11, ACL-RSI, K-SES)

Phase 3

Goal: return to sport or physically demanding work.

*1. Level of body functions and structures*

*a. Mobility*

- Maintain full patellofemoral and tibiofemoral range of motion.<sup>51</sup>

*b. Strength training*

- Intensify (sport) specific strength training.<sup>51,87,149</sup>

*2. Level of activities and participation*

*a. Neuromuscular training*

- Increase difficulty of neuromuscular and perturbation training:
  - o with single-legged jumps,
  - o with emphasis on sport specific movements.<sup>51,87</sup>
- Keep paying attention to a correct quality of performance during strength training, walking, jogging, and sport specific exercises.

*b. Walking and bicycling*

- Enhance bicycling or jogging in intensity and duration. Built sport specific load concerning energy expenditure (anaerobic lactic, anaerobic alactic, aerobic) and surface (for example soccer field, road, forest or sports hall).

*c. Sport specific training*

- Increase and intensify agility training.<sup>87</sup>
- Restart training at the patient's own sports club.

*Criteria for return to play:*

- No knee pain at sport specific activities.
- No giving way or fear of giving way during sport specific activities.
- Active dynamic gait pattern, symmetrical jogging pattern<sup>143</sup>, and correct quality of performance with all sport specific activities.
- LSI >90% for quadriceps and hamstring strength (to exclude quadriceps dominance and leg dominance).<sup>51,158</sup>
- LSI >90% for a hop test battery<sup>51</sup>, with preference towards the hop test battery of Gustavsson<sup>156</sup>, with the single-leg hop-and-hold test added (to exclude quadriceps dominance and leg dominance).<sup>158</sup>
- Drop jump test with observation or video-analysis of the quality of movement, at least measuring trunk lateroflexion, dynamic knee valgus (to exclude ligament dominance) and the knee flexion angle when landing.<sup>32,157,159</sup>
- Complete the IKDC Subjective knee evaluation form and/or KOOS.
- Complete a psychological questionnaire (TSK-11, ACL-RSI, K-SES).